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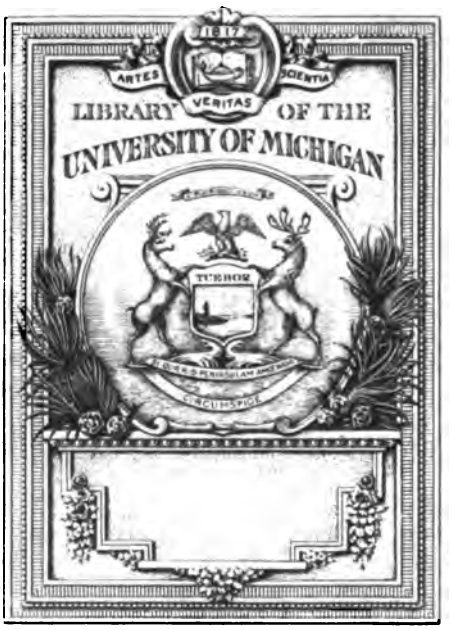
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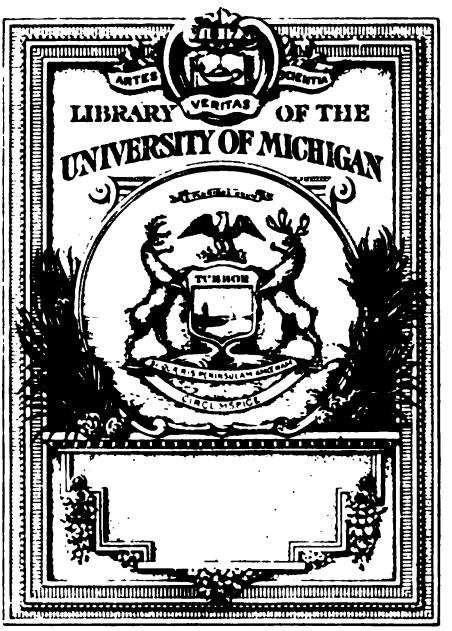
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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FEEDING STUFFS

by J. L. HILLS, C. H. JONES and G. F. ANDERSON

CONCERNING THE OAT CROP

by J. L. HILLS

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General

BULLETIN 197: COMMERCIAL FEEDING STUFFS

By J. L. Hills, C. H. Jones and G. F. Anderson

CONCERNING THE OAT CROP

By J. L. Hills

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I. SUMMARY

More than 700 samples representing over 400 different brands of feeding stuffs were analyzed in the 1916 inspection. The results were distinctly disappointing—the worst in years. They may be summarized as follows:

If we may judge of the entire trade by the samples drawn by the Station—and there is no other criterion by which to judge—

1. Half of the cottonseed meal sold last fall, winter and spring in Vermont were not what they were represented to be in respect to their protein contents.
2. One-fifth of the distillers' dried grains was similarly deficient.
3. A third of the brewers' dried grains was similarly deficient.
4. One out of six of the wheat feeds was similarly deficient.
5. One out of five proprietary stock feeds was similarly deficient.

Speaking broadly, Vermonters during the past feeding season have been paying more for poorer goods than at any time during the last twenty years.

What can they do about it? Little or nothing except to watch the bulletin statements and do what they can to buy brands which seem likely—in view of their past history—to be as good as they are said to be, provided their promises are adequate. It would, of course, be farcical to buy a low grade goods at a high price because the guaranty was maintained instead of a high graded brand at a medium or, indeed, high price because it was not quite as good as it was said to be. In other words, guaranty maintenance is but one of several factors which should be borne in mind in determining the choice of feed. However, as between two brands of the same class and same guarantied protein content, other things being equal, farmers would do well to buy the brand whose record is lily white rather than one whose past history is blemished by exaggerated guaranty claims. The statements on pages 13 to 45, alphabetically arranged by manufacturers' or jobbers' names within classes, will enable anyone readily to determine the facts concerning any feeding stuff as developed in the past season's inspection.

II. INTRODUCTION

The sampling agents of the Station visited 68 towns and villages in Vermont in late December, 1915, and early January, 1916, and in March and April, 1916, and drew 719 samples from dealers' stocks, representing over 400 brands of goods which either are subject to or exempt from the necessity of guaranty. The entire state was fairly well covered except Essex County. The larger wholesale and many retail places were visited twice, but points remote from the railroad were not often reached. All of these samples were examined chemically for protein. Both guarantied and unguarantied goods were analyzed; the former to determine so far as might be learned their purity, as well as the maintenance of the standards fixed by the manufacturers; the latter to determine, if possible, whether as a matter of fact the goods were pure and, hence, not subject to guaranty.

Only the protein contents of the samples were determined.

The reader who may be interested in the economics of feed purchase is referred to matter on pages 34 to 44 of bulletin 144, as well as to that on pages 582 to 590 of bulletin 152. Full descriptions of the nature and manufacture of the various goods offered on the Vermont market will be found on pages 22 to 34 of bulletin 144, together with a discussion of the advisability or inadvisability of their purchase, as the matter appealed to the writer when the bulletin was written.

SYNOPSIS OF THE PUBLIC STATUTES DEALING WITH FEEDING STUFFS

The essentials of the Vermont feeding stuff law are as follows:

Sections 4983-4. *Definition of the term "concentrated commercial feeding stuff";* including the common feeds other than hay, straw, whole seeds and unmixed meals, wheat, rye and buckwheat offals.

Section 4985. *Statement of contents;* net weight, brand name and address of manufacturer, minimum percentages of crude protein and crude fat, maximum percentage of crude fiber, and the specific name of each ingredient used in manufacture.

Section 4986. *Illegal sales; penalty.* The omission of the guaranty, a material overstatement of the actual protein or fat contents or understatement of the actual fiber contents, and the omission of or incorrect statement of the specific name of each ingredient are forbidden; fine, not to exceed fifty dollars for the first or one hundred dollars for each subsequent offense.

Section 4987. *Adulterations; exceptions; penalty.* The adulteration of whole or ground grain, or of bran, middlings or mixed

feed with offals, unless the fact is stated on each package, and the inclusion of more than two percent by weight of weed seeds unless stated on each package, are forbidden; fine, not less than twenty-five dollars nor more than one hundred dollars.

Section 4988. *Appropriation; expenses; report.* Five hundred dollars annual appropriation; annual financial statement to be published by the Station.

Section 4989. *Prosecutions.* Notice to dealer giving thirty days time wherein to comply with law; failing which, report is made to state's attorney; no prosecution in relation to quality if the same is substantially equivalent to the guaranty.

Section 4990. *Collection of samples.* Authorization to enter and take samples; not less than five percent of entire lot to be sampled, thoroughly mixed, sealed and labelled; samples to be taken in duplicate if requested by the dealer.

Section 4991. *Analyses of samples; publication.* One sample of each brand to be analyzed; results, together with additional information in relation to the character, composition, value and use of feeding stuffs, shall be published.

Section 4992. *Exception.* Act does not apply to persons purchasing feeding stuffs for their own use and not for sale.

Section 4993. *Obstructing director; penalty.* Provision against hindrance in execution of law.

On the whole the law is well observed at present. In a few cases, particularly when mixtures are locally made in a small way by Vermont dealers, the packages do not declare their contents in terms of ingredients as is now required by law. Unguarantied goods are infrequent at the present time and overguaranties are not as common as once they were; but overstatements in advertising still occur. The law cannot control extravagant statements in the press or elsewhere. It is for the buyers to look askance thereat and to ask the Station as to the facts.

It is not generally appreciated that there is a federal law which aids in preventing misbranding, misstatement and adulteration of such goods as may enter into interstate commerce. The state law, of course, cannot hold outside of state lines; but serious cases of fraud may be reported to federal authorities. In this way local dealers who sell in good faith need not be troubled to any great extent and the parties actually responsible for illegal sales may be reached.

It is but just, both to the consumer and to the Station, to say in this connection that the inspection of commercial feeding stuffs in Vermont is extremely inadequate; that in comparison with that done in other states it is almost pitiable in its inability to meet the real needs of the buyer. This is not the fault of the Station, which does what it can with a very small appropriation, many times smaller, it is believed, than that which is available in any other state. It should be remarked in this connection, however, that in view of the fact that police duties of this character are not the essential function—indeed, strictly speaking, not a proper function—of an experiment station but are excrescences, it is not a situation which causes its administration any worriment. The Station neither desires nor intends to campaign for increased appropriations in the interests of a more thorough inspection of the trade in commercial feeding stuffs; nor does it mean to agitate towards that end. It simply seeks thus to set forth in self-defence the reason why its work is relatively ineffective.

REVISED METHOD OF STATEMENT OF ANALYTICAL RESULTS

The system of statement of analyses hitherto in use has not proved satisfactory. The results have not been set forth in as clear fashion as might be desired, they have been in many instances located on different pages, and the meaning of the analytical figures, though few in number, were not always apprehended by bulletin readers. Hence another system has been employed in this bulletin, whereby for each feeding stuff there are shown in a single paragraph:

1. The name and address of the manufacturer.
2. The name and address—or names and addresses—of the local dealer or dealers from whose stocks the samples were drawn.
3. The brand name.
4. The "specific name of each ingredient used in (the) manufacture" of the feeding stuff, in case it is a compounded material, as stated by the manufacturers upon bag or tag.
5. The percentage of crude protein guaranteed by the manufacturers to be present.
6. The accuracy of the manufacturer's protein guaranty, stated not in terms of figures but in terms of words:—using the phrase "guaranty fulfilled" if as a matter of fact the goods contained as much protein as they were said to contain, or the phrase "but failed by—percent to fulfill guaranty" if as a matter of fact the goods did not contain as much crude protein as they were said to contain.

Within classes, the order of arrangement is alphabetical by manufacturers' names, following the system now used in fertilizer and seed inspection bulletins. Makers' names are printed in small capitals; brand names and guaranties are printed in italics.

This system groups within a single paragraph all the information which the Station is able to purvey concerning a given sample. Not all that might be given to advantage, not all that is usually given in the feeding stuffs inspection bulletins of other states, but all that can be furnished in view of the meagre appropriation. No attempt is made to show the fat and crude fiber guaranties, since it is impossible for the Station to assert whether or not they are accurate. They are shown on each package and a would-be buyer can readily determine for himself what they are in any given case. In several cases more than one sample, either single or composite, was analyzed. This means usually that samples were drawn both in the midwinter and in the early spring sampling trips; the samples for the one being analyzed in January, and for the other in April.

A further advantage derived from a method of statement which does not indicate to what extent, if any, a protein guaranty is exceeded is that occasionally the analytical data are misleading to the purchaser. A given sample may be very high in protein, far in excess of its guaranty, in a certain inspection, due to some slip in formula making or otherwise; and buyers may be thus mislead. Notwithstanding the fact that some samples may carry higher protein contents then their guaranties indicate, it is always safe to assume the manufacturer's promise as a basis of purchase, except in cases where the station bulletin shows that guaranties are not maintained. That is all that one can safely go by; that is all the law is meant to do, to make it as certain as may be that manufacturers' promises mean what they say; that they "state what they sell and sell what they state," neither more nor less.

From the standpoint of the enforcement of the law, the important matter is simply this: do the goods contain what they are said to contain.

Concerning the phraseology in tabular matter, in cases where guaranties are not made good, it should be said that in cases where the deviation was but a fraction of a percent, no stress should be laid upon the shortage, unless it be that the crude protein guaranty is a low one, say 12 percent or less. Of course a one-half percent deficiency in a goods guarantied to contain but 10 percent protein is equivalent to a shortage of $\frac{1}{20}$ or 5 percent, whereas a similar lack in a cotton-

seed meal, guarantied to carry 41 percent, would be but $\frac{1}{82}$ or but little more than 1 percent of the promised amount.

Concerning the phraseology used by some manufacturers in naming the "specific ingredients" it may be said that the Standard Dictionary defines an "ingredient" to be "that which is placed in or specifically enters into the constitution of any mixture or compound, or is a component part of any conglomerate; component; part; as, the ingredients of gunpowder are niter, charcoal and sulphur." Now "clipped oat byproducts," "oat feed," etc., are not ingredients, but combinations of ingredients, just as gunpowder is not an ingredient but a combination of ingredients; hence labels carrying such statements are considered to be illegal and are so designated in the tabular matter.

STANDARDS: AVERAGE COMPOSITION

A standard is defined to be "a measure of quality established by law or by general usage or consent; any type, model, example or authority with which comparison may be made; any fact, thing or circumstance forming a basis for adjustment and regulation." Now standards, i. e., "measures of quality," "examples with which comparison may be made," are of service in connection with the use of feeding stuffs. Thus one is able the better to pass judgment on the worth of a given sample. The percentages of protein, fat and fiber form in part the basis of judgment in this connection. If a given sample is of good appearance, neither moldy, rancid nor in other ways spoiled, is mechanically in good condition, is free from objectionable foreign matter and carries approximately the protein and fat percentages and not materially more than the fiber content shown below, it is probably safe to assume it to be of standard quality.

The following table of averages indicates closely the average composition of the goods more commonly sold in Vermont.

	Protein	Fat	Fiber
I. GOODS CARRYING MORE THAN 30 PERCENT PROTEIN			
Cottonseed meal (choice)	41.	9.5	7.
Cottonseed meal (prime and good)	36.	8.	8.
Linseed meal (new process)	36.8	2.8	9.
Linseed meal (old process)	34.1	7.6	9.
Distillers' dried grains (first grade)	31.6	13.1	12.
II. GOODS CARRYING 25 TO 30 PERCENT PROTEIN			
Buckwheat middlings	29.1	7.5	5.
Distillers' dried grains (second grade)	27.5	11.5	13.
Brewers' dried grains	26.1	7.1	12.
Malt sprouts	26.5	1.5	12.5

	Protein	Fat	Fiber
III. GOODS CARRYING 20 TO 25 PERCENT PROTEIN			
Gluten feeds	23.7	3.	7.5
IV. GOODS CARRYING 15 TO 20 PERCENT PROTEIN			
Molasses feeds (as a class) exclusive of horse feeds	16.2	3.4	12.
Wheat middlings	17.1	5.1	5.
Wheat mixed feed	16.2	4.8	9.
Wheat bran	15.2	4.7	10.
V. GOODS CARRYING 10 TO 15 PERCENT PROTEIN			
Molasses feeds for horses (as a class)	12.4	3.3	15.
Fortified oat feeds	12.9	3.8	8.
Alfalfa meals	13.1	1.3	28.
Hominy meal	10.5	8.4	4.5
Ground oats	10.6	4.8	10.
VI. GOODS CARRYING 5 TO 10 PERCENT PROTEIN			
Corn and oat feeds (as a class)	9.2	5.1	9.
Provender	9.2	4.3	6.
Oat feeds (as a class)	6.8	3.1	20.
Corn meal	8.9	3.4	2.
Dried beet pulp	8.	0.3	18.
VII. POULTRY FEEDS			
Meat scraps	50.	15.	..
Meat and bone meals	40.	10.	..
Mashes	16.	4.	7.
Chick feed	12.	3.	3.
Scratch feed	11.	3.	3.

DEFINITIONS[1] OF FEEDING STUFFS AND "INGREDIENTS"

The feeding stuffs law, as amended by the General Assembly of 1912, requires that "the specific name of each ingredient used in its manufacture" be stated on "each lot or parcel of concentrated commercial feeding stuff." Manufacturers have not in all cases complied with this feature of the law.

Cottonseed meals, linseed meals, gluten feeds, distillers' dried grains, brewers' dried grains, malt sprouts, dried beet pulp, hominy feed, ground beef or fish scraps, all of them "concentrated commercial feeding stuffs" as defined in Section 4983 P. S., if true to name and not sold under some trade name not indicative of their true nature, are not held to be compounded materials and, hence, no special statement as to "ingredients" need appear on the package.

Cottonseed feeds, molasses feeds, oat feeds, corn and oat feeds, proprietary mixtures and mixed feeds (not wheat mixed feeds free from adulteration or from wheat screenings), condimental stock and poultry foods, and stock feeds, must now carry on each package a statement of their ingredients. Lack of funds prevents any careful survey of the samples to determine whether or not as a matter of fact the statements of ingredients made by the manufacturer are accurate. On account of its lack of information the Station expresses no opinion as to whether in any given case manufacturers' statements in this respect are or are not reliable. However, it knows of no reason to allege inaccuracy in any case. The manufacturers' statements occur on pages 29 to 40.

Cottonseed meal is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 percent of protein.

Choice cottonseed meal must be finely ground, not necessary bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and must contain at least 41 percent of protein.

[1] In the main those adopted by the Association of Official Feed Analysts.

Prime cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 percent protein.

Good cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 percent protein.

Linseed meal is the ground residue after extraction of part of the oil from ground flaxseed. The "old process" meal is made from crushed flaxseed which has been heated and subjected to hydraulic pressure; the "new process" meal is made from crushed flaxseed which has been extracted after heating by repeated leachings with light naphtha, all traces of which are removed by steam treatment. The latter goods carry but half the fat content of the former and usually from one to two percent more protein.

Corn starch byproduct with corn bran (the entire coating of the corn kernel) is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the processes employed in the manufacture of corn starch and glucose. It may or may not contain corn solubles.

Gluten feed is a product obtained in the manufacture of starch and glucose from corn and is a mixture of gluten meal, corn bran, germ residues, and, permissibly, "steep water" residues. It consists largely of the flinty portion of the outer coatings of kernel, being essentially the corn grain with its starchy portion largely removed.

Distillers' dried grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation of the cereal predominating.

Brewers' dried grains are the properly dried residue from cereals obtained in the manufacture of beer.

Proprietary feeds are admixtures made by manufacturers of a greater or less number of feeding stuffs, high grade, low grade or both. A statement of the ingredients, but not the proportions or "formula," must be declared upon each package.

Hominy meal, hominy feed, or hominy chop is a mixture of the bran coating, the germ and a part of the starchy portion of the corn kernel obtained in the manufacture of hominy grits for human consumption.

Corn and oat feeds are proprietary mixtures into the compounding of which enter considerable quantities of oat by-products as well as corn. They usually carry less than 12 percent protein and from 8 percent upwards of crude fiber. "Chop" is a ground or chop feed composed of one or more different cereals or the by-products therefrom.

Alfalfa meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

Dried beet pulp is the dried sugar beet residue obtained in the manufacture of beet sugar, with or without an admixture of beet molasses.

Calf meals are proprietary feeds intended as whole or partial substitutes for milk in the feeding of young calves.

Meat scrap and meat meal are the ground residues from animal tissue exclusive of hoof and bone. If they contain any considerable amount of bone, they must be designated meal and bone scrap, or meat and bone meal. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Rye feeds are by-products obtained in the manufacture of rye flour.

III. RESULTS OF INSPECTION

The following statements touching the results of the inspection cover the entire lot of samples drawn during the past winter and spring. They do not include the multitudinous samples sent in by local dealers. The results are listed in the order as shown in the table of contents, page 3, and occur on pages 13 to 40.

COTTONSEED MEALS

F. W. BRODÉ & Co., Memphis Tenn. Chas. M. Seaver, Williamstown; H. S. Buttles' Estate, Brandon; Richmond & Son, Northfield; J. D. Thompson, Norwich; J. G. Turnbull & Co., Orleans; Swerdferger & Davis, Marshfield. *Owl.* Guaranteed to contain *41* percent crude protein but failed by 3¼ percent to fulfill guaranty (winter sampling).

F. W. BRODÉ & Co., Memphis Tenn. W. C. Ballou, Newfane; S. P. Curtis & Son, Rutland; Kempton Mills, Barre; A. H. McLeod Milling Co., St. Johnsbury; H. Parker, North Troy. *Owl.* Guaranteed to contain *41* percent crude protein, but failed by 5 percent to fulfill guaranty (spring sampling).

F. W. BRODÉ & Co., Memphis, Tenn. L. L. Marsh, Enosburg Falls. *Dove.* Guaranteed to contain *38.63* percent crude protein; guaranty fulfilled.

BUCKEYE COTTON OIL Co., Cincinnati, O. E. W. Bailey & Co., Montpelier; A. H. McLeod Milling Co., St. Johnsbury; E. E. Harris & Co., Morrisville. *Buckeye Prime.* Guaranteed to contain *38.62* crude protein; guaranty fulfilled (winter sampling).

BUCKEYE COTTON OIL Co., Cincinnati, O. A. H. McLeod Milling Co., St. Johnsbury. *Buckeye.* Guaranteed to contain *38.62* percent crude protein, but failed by one percent to fulfill guaranty (spring sampling).

S. P. DAVIS, Little Rock, Ark. Chas. M. Seaver, Williamstown; J. G. Turnbull & Co., Orleans. *Good Luck.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled (winter sampling).

S. P. DAVIS, Little Rock, Ark. Davis Feed Co., Rutland; A. G. Spaulding, Ludlow; Chas. M. Seaver, Williamstown. *Good Luck.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled (spring sampling).

DIXIE COTTON OIL Co., Montgomery, Ala. W. R. White, North Bennington. *Prime.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled.

EMPIRE COTTON OIL Co., Atlanta Ga. City Feed Co., St. Albans. *Gilt Edge.* Guaranteed to contain *38* percent crude protein; guaranty fulfilled (winter sampling).

EMPIRE COTTON OIL Co., Atlanta, Ga. C. E. Miller, Wells River; City Feed Co., St. Albans; H. I. Randall, Wolcott. *Gilt Edge.* Guaranteed to contain *38* percent crude protein, but failed by a little more than a half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. W. Bailey & Co., Montpelier; A. N. Washburn, Bethel; Richmond & Son, Northfield; E. I. Benson, Woodstock; A. B. Kilbourne, Bristol; L. L. Marsh, Enosburg Falls; R. S. Clark, Barre; Clark & Davidson, Groton. *Dixie.* Guaranteed to contain *38.62* percent crude protein, but failed by nearly two percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. W. Bailey & Co., Montpelier; Burditt Bros., Rutland; S. P. Curtis & Son, Rutland; E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman, Newport. *Dixie.* Guaranteed to contain *38.62* percent crude protein, but failed by one and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. T. Seabury Estate, Waterbury; H. K. Foster, South Royalton. *Bull.* Guaranteed to contain *41* percent crude protein, but failed by two and one-half percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN CO., Memphis, Tenn. E. T. Seabury Estate, Waterbury. *Bull.* Guaranteed to contain *41* percent crude protein, but failed by three and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN CO., Memphis, Tenn. E. E. Harris & Co., Morrisville; Richmond Lumber Co., Richmond. *Forfat.* Guaranteed to contain *38.55* percent crude protein, but failed by one and two-thirds percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN CO., Memphis, Tenn. Burlington Flouring Co., Burlington. *Forfat.* Guaranteed to contain *38.55* percent crude protein, but failed by one and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN CO., Memphis, Tenn. C. O. Fowler, North Troy. ———. Guaranteed to contain *37.84* percent crude protein; guaranty fulfilled (spring sampling).

LANIER BROS., Nashville, Tenn. A. D. Pease, Burlington. *Canary.* Guaranteed to contain *41* percent crude protein, but failed by one percent to fulfill guaranty (spring sampling).

J. M. MACDONALD, Cincinnati, O. A. H. McLeod Milling Co., St. Johnsbury. *Kineda.* Guaranteed to contain *38.6* percent crude protein; guaranty fulfilled (winter sampling).

J. M. MACDONALD, Cincinnati, O. F. D. Lapelle, Swanton. *Kineda.* Guaranteed to contain *38.6* percent crude protein, but failed by one and one-quarter percent to fulfill guaranty (spring sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. Griswold & Mackinnon, St. Johnsbury; Mathews & Hall, Orleans. *Canary.* Guaranteed to contain *38.63* percent crude protein; guaranty fulfilled (winter sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. R. L. Clark & Co., Barre. *Canary Extra.* Guaranteed to contain *41* percent crude protein, but failed by two-thirds of one percent to fulfill guaranty (spring sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. H. I. Randall, Wolcott. *Canary.* Guaranteed to contain *38.63* percent crude protein, but failed by almost three percent to fulfill guaranty (spring sampling).

J. E. SOPER CO., Boston, Mass. E. G. & A. W. Norton, Vergennes; J. G. Turnbull & Co., Orleans; H. E. Shaw, Stowe; E. T. & H. K. Ide, St. Johnsbury; G. S. Welsh, Groton. *Pioneer.* Guaranteed to contain *41* percent crude protein, but failed by almost two percent to fulfill guaranty (winter sampling).

J. E. SOPER CO., Boston, Mass. E. T. & H. K. Ide, St. Johnsbury; A. D. Pease, Burlington; J. G. Turnbull & Co., Orleans; F. H. Walker Manchester. *Pioneer.* Guaranteed to contain *41* percent crude protein, but failed by more than three percent to fulfill guaranty (spring sampling).

UNION BROKERAGE AND COMMISSION CO., Vicksburg, Miss., and New Orleans, La. A. D. Pease, Burlington. *Durjan.* Guaranteed to contain *41* percent crude protein, but failed by one-third of a percent to fulfill guaranty (spring sampling).

UNION SEED & FERTILIZER CO., Huntsville, Ala. W. R. White, North Bennington. *American Red Tag.* Guaranteed to contain *38.55* percent crude protein; guaranty fulfilled (winter sampling).

UNION SEED & FERTILIZER CO., Clarksdale, Miss. E. T. & H. K. Ide, St. Johnsbury; E. Crosby & Co., Brattleboro. *American Red Tag.* Guaranteed to contain *38.55* percent crude protein; guaranty fulfilled (spring sampling).

LINSEED MEALS

AMERICAN LINSEED CO., New York, N. Y. G. W. Rose, Middlebury. *Hypro Pure* (*"new" process*). Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED CO., New York, N. Y. A. D. Pease, Burlington. *Hypro Pure* (*"new" process*). Guaranteed to contain *38* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED CO., New York, N. Y. I. Gray, West Danville. ——— (*"new" process*). Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED Co., New York, N. Y. H. S. Buttles' Estate, Brandon; R. L. Clark, Barre; Richmond & Son, Northfield; J. E. Foster, Underhill; Madden & Trumbull, White River Junction. *Old Process.* Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED Co., New York, N. Y. City Feed Co., St. Albans; St. Albans Feed Co., St. Albans; Clark & Devine, Northfield; E. W. Bailey & Co., Montpelier. *Old Process.* Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

MIDLAND LINSEED PRODUCTS Co., Minneapolis, Minn. A. B. Kilbourne, Bristol; C. E. Miller, Wells River; E. W. Bailey & Co., Montpelier. *Old Process.* Guaranteed to contain *32* percent crude protein; guaranty fulfilled.

MINNESOTA LINSEED OIL Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro. ———. Guaranteed to contain *38* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. Geo. Shorey, Lyndonville. *Old Process.* Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. Swerdfeger & Davis, Marshfield; J. H. Hewitt, South Royalton; H. Waite & Son, Morrisville. *Old Process.* Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. L. L. Marsh, Enosburg Falls; R. L. Clark, Barre; E. Crosby & Co., Brattleboro. *Old Process.* Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

TOLEDO SEED & OIL Co., Toledo, O. John Burdick, Wallington; A. H. McLeod Milling Co., St. Johnsbury. *Old Process.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

TOLEDO SEED & OIL Co., Toledo, O. A. H. McLeod Milling Co., St. Johnsbury; Bradford Mill, Bradford; Burditt Bros., Rutland; Burditt Bros., Ludlow. *Old Process.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

GLUTEN FEEDS AND MEAL

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. E. T. & H. K. Ide, St. Johnsbury; MacDiarmid & Co., Newport. *Cream of Corn.* Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. L. L. Marsh, Enosburg Falls. *Cream of Corn.* Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. A. B. Kilbourne, Bristol. *Cream of Corn.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CLINTON SUGAR REFINING Co., Clinton, Io. Richmond & So., Northfield; F. M. Sherman & Son, Newport; E. W. Bailey & Co., Montpelier. *Clinton.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CLINTON SUGAR REFINING Co., Clinton, Io. Chas. M. Seaver, Williamstown; F. M. Sherman & Son, Newport; Geo. Shorey, Lyndonville. *Clinton.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. E. T. Seabury Estate, Waterbury; Half Century Store Co., Randolph; G. W. Marble, Woodstock. *Diamond Corn Gluten Meal.* Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. Charlotte Feed Co., Charlotte; J. D. Thompson, Norwich; City Feed Co., St. Albans; H. A. Gray, Cambridge; Kempton Mills, Barre. *Buffalo.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. Burditt Bros., Rutland; Kempter Mills, Barre; E. T. & H. K. Ide, St. Johnsbury; Nelson Bros., Springfield; J. G. Turnbull & Co., Orleans. *Buffalo.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. E. W. Bailey & Co., Montpelier. *Crescent.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. S. Sherman & Son, Poultney. *Globe.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DOUGLAS CO., Cedar Rapids, Ia. Farmers' Exchange, Bradford; H. S. Buttles' Estate, Brandon; H. B. Parkhurst, North Troy; Clark & Devine, Northfield. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DOUGLAS CO., Cedar Rapids, Io. Burditt Bros., Rutland; Guild Grain Store, Ludlow; Richmond Lumber Co., Richmond. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

J. C. HUBINGER BROS. CO., Keokuk, Ia. C. W. Sherman Estate, West Rupert; S. Sherman & Son, Inc., Poultney. *KKK.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

A. E. STALEY MANUFACTURING CO., Decatur, Ill. Clark & Devine, Northfield. *Staley's.* Guaranteed to contain *23* percent crude protein, but failed by about one-half percent to fulfill guaranty.

DISTILLERS' DRIED GRAINS

AJAX MILLING AND FEED CO., New York, N. Y. L. L. Marsh, Enosburg Falls; Burditt Bros., Brandon; Wm. Morrison, Barnet. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

AJAX MILLING AND FEED CO., Hammond, Ind. Davis Feed Co., Rutland. Griswold & Mackinnon, St. Johnsbury; Guild Grain Store, Ludlow. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

CLARKE BROS. & CO., Peoria, Ill. H. E. Shaw, Stowe; J. D. Thompson, Norwich; E. E. Harris & Co., Morrisville. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein, but failed by a half percent to fulfill guaranty.

CLARKE BROS. & Co., Peoria, Ill. E. W. Bailey & Co., Montpelier; I. Gray, West Danville; L. L. Marsh, Enosburg Falls. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. L. L. Marsh, Enosburg Falls; Charlotte Feed Co., Charlotte; Miles, McMahon & Son, Stowe. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. C. E. Miller, Wells River. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein, but failed by nearly one percent to fulfill guaranty.

DEWEY BROS. CO., Blanchester, O. R. Webster & Son, Barton; C. E. Miller, Wells River; E. Crosby & Co., Brattleboro. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. E. T. Seabury Estate, Waterbury. *Corn 3D.* Guaranteed to contain *26* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. F. D. Lapelle & Co., Swanton. *Corn 3D.* Guaranteed to contain *26* percent crude protein; guaranty fulfilled.

GRAIN PRODUCTS SALES CO., Buffalo, N. Y. L. A. Sheldon, Rupert. *Columbia.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

HOTTELET CO., Milwaukee, Wis. E. T. & H. K. Ide, St. Johnsbury; Half Century Store Co., Randolph; H. A. Slayton & Co., Morrisville; Chas. M. Seaver, Williamstown; G. S. Welsh, Groton. *Hector.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

HOTTELET CO., Milwaukee, Wis. Walker & Brock, Barnet; Bradford Mills, Bradford; E. Crosby & Co., Brattleboro; St. Albans Feed Co., St. Albans. *Hector.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

UBIKO MILLING CO., Cincinnati, O. H. K. Foster, South Royalton; Sweat-Comings Co., Richford. *Fourex.* Guaranteed to contain *31* percent crude protein, but failed by nearly a half percent to fulfill guaranty.

UBIKO MILLING CO., Cincinnati, O. E. L. Kibby, Williamstown; St. Albans Grain Co., St. Albans. *Fourex.* Guaranteed to contain *30* percent crude protein, but failed by two and three-quarters percent to fulfill guaranty.

BREWERS' DRIED GRAINS

ANHEUSER-BUSCH BREWING ASSOCIATION, St. Louis, Mo. E. G. & A. W. Norton, Vergennes. ———. Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

ANHEUSER-BUSCH BREWING ASSOCIATION, St. Louis, Mo. Guild Grain Store, Ludlow. ———. Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

ATLANTIC EXPORT Co., Chicago, Ill. Perley & Leavens, Cambridge. ———. Guaranteed to contain *25* percent crude protein, but failed by three and three-quarters percent to fulfill guaranties.

FARMERS' FEED Co., Buffalo, N. Y. E. I. Benson, Woodstock; City Feed Co., St. Albans; A. B. Kilbourne, Bristol; E. H. Edson, Randolph; Richmond Lumber Co., Richmond. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FARMERS' FEED Co., Buffalo, N. Y. L. L. Marsh, Enosburg Falls; E. W. Bailey & Co., Montpelier; S. P. Curtis & Son, Rutland; Griswold & Mackinnon, St. Johnsbury; R. Webster, Barton. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FLEISCHMANN Co., Chicago, Ill. John Burdick, Wallingford. *Fleischmann's.* Guaranteed to contain *19* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

WHEAT OFFALS

WHEAT BRANS

BILL, BELL & Co., Ogdensburg, N. Y. H. S. Buttles' Estate, Brandon. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.25* percent crude protein; guaranty fulfilled.

BLAKE MILLING Co., Edwardsville, Ill. F. D. Lapelle & Co., Swanton. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

BOWERSOCK MILLS & POWER Co., Lawrence, Kan. J. G. Turnbull & Co., Orleans. *Pure Bran* with screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington, Vt. *Perfection Cereal Bran.* (Unguarantied). Contained 12.1 percent crude protein.

GEO. C. CHRISTIAN, Minneapolis, Minn. Geo. J. Stannard, Fair Haven; E. T. & H. K. Ide, St. Johnsbury. *Jersey Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

CLARO MILLING Co., Lakeville, Minn. City Feed Co., St. Albans. *Claro Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WM. A. COOMBES MILLING Co., Coldwater, Mich. *Bran* with screenings. E. T. & H. K. Ide, Bradford. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

EAGLE ROLLER MILL Co., New Ulm, Minn. Griswold & Mackinnon, St. Johnsbury. *Bran.* Guaranteed to contain *15.45* percent crude protein; failed by a half percent to fulfill guaranty.

B. A. ECKHARDT MILLING Co., Chicago, Ill. E. Lane & Son, Newport. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. A. N. Washburn, Bethel. *Dairy Maid Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. C. E. Miller, Wells River. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. E. Lane & Son, Newport. *Lucky Spring Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

GWINN MILLING Co., Columbus, O. Griswold & Mackinnon, St. Johnsbury. *Gwinn's Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. E. I. Benson, Woodstock. *Choice Bran* with trace of screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HUNTER-ROBINSON-WENZ MILLING Co., St. Louis, Mo. C. McFarland & Son, Barton; Griswold & Mackinnon, St. Johnsbury. *Dreadnought Xtra Coarse Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

HUNTER-ROBINSON-WENZ MILLING Co., St. Louis, Mo. Geo. J. Stannard, Fair Haven; C. W. Hartwell, Newbury. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

KEHLER FLOUR MILLS Co., St. Louis, Mo. John Burdick, Wallingford. *Palace Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. C. W. Sherman's Estate, West Rupert; H. M. Brown, Castleton; E. H. Mason, Randolph; E. Lane & Son, Newport; E. W. Bailey & Co., Montpelier; Swerdfeger & Davis, Marshfield; J. D. Thompson, Norwich. *Anchor Bran* with ground screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

LEE WARREN MILLING Co., Salina, Kans. Burlington Flouring Co., Burlington. *Bran* and screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LIBERTY MILLS, Nashville, Tenn. Strong & Goddard, Hyde Park. *Pure Bran* with screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., ————. Charlotte Feed Co., Charlotte. *Elmco Bran.* Guaranteed to contain *15.51* percent crude protein; guaranty fulfilled.

MANEY MILLING Co., Omaha, Neb. L. S. Robie, Hardwick. *Bran* with screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

MANSFIELD MILLING Co., ————. Burditt Bros., Rutland. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

MAPLE LEAF MILLING Co., LTD., Toronto, Can. H. B. Parkhurst, North Troy. *Bran.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NATIONAL MILLING Co., Toledo, O. MacDiarmid & Co., Newport. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.5* percent crude protein; contained almost 3 percent less than guaranty, a shortage of one-sixth the total amount.

NATIONAL FEED Co., St. Louis, Mo. L. L. Marsh, Enosburg Falls. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. E. H. Mason, Randolph; E. T. & H. K. Ide, Bradford. *Choice Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Mathews & Hall, Orleans; Half Century Store Co., Randolph; H. K. Foster, South Royalton; Griswold & Mackinnon, St. Johnsbury. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Fort William, Ont. Geo. Shorey, Lyndonville. *Fancy Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein, but failed by three-quarters of a percent to fulfill guaranty.

OGILVIE FLOUR MILLS Co., Fort William, Ont. Star Feed Store, Burlington. *Fancy Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PELICAN RIVER MILLING Co., Elizabeth, Minn. E. T. & H. K. Ide, St. Johnsbury. ————. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Pillsbury's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. E. Lane & Son, Newport; A. B. Kilbourne, Bristol; H. E. Shaw, Stowe. *Pillsbury's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. J. G. Turnbull Co., Orleans. *Pillsbury's Duram Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

GEO. P. PLANT MILLING Co., St. Louis, Mo. Chas. M. Seaver, Williamstown. *Bran* with screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. G. W. Marble, Woodstock. *Bell Cow Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

RED WING MILLING Co., Red Wing, Minn. City Feed Co., St. Albans. *Bixota Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.1* percent crude protein; guaranty fulfilled.

RED WING MILLING Co., Red Wing, Minn. A. D. Pease, Burlington. *Bixota Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.1* percent crude protein; guaranty fulfilled.

ROYAL MILLING Co., Great Falls, Mont. E. T. & H. K. Ide, St. Johnsbury. *Royal Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. E. T. Seabury Estate, Waterbury. *Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

SOUTHWESTERN MILLING Co., Kansas City, Mo. Madden & Trumbull, White River Junction; E. H. Mason, Randolph. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. G. W. Rose, Middlebury. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. R. P. Webster, Barton; C. E. Miller, Wells River. *Winter Bran* with wheat screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. C. E. Miller, Wells River; Kempton Mills, Barre. *Spring Bran* with wheat screenings. Guaranteed to contain *16* percent crude protein, but failed by almost one percent to fulfill guaranty.

TENNENT & HOYT Co., Lake City, Minn. E. W. Bailey & Co., Swanton. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. C. W. Sherman Estate, West Rupert. *Winter Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. MacDiarmid & Co., Newport. *Voight's Bran* with mill-run of screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. E. T. & H. K. Ide, Fairlee; H. E. Shaw, Stowe. *Voight's Bran* with mill-run of screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. L. L. Marsh, Enosburg Falls; A. B. Kilbourne, Bristol; E. R. Sheldon, Rupert. *Washburn-Crosby's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

WESTERN CANADA FLOUR MILLING Co., LTD., ————. E. T. & H. K. Ide, Fairlee; Richmond & Son, Northfield; Sweat-Comings Co., Richford. *Spring Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

WESTERN FLOUR MILL Co., Davenport, Ia. Geo. J. Stannard, Fair Haven. *Blackhawk Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

YERXA, ANDREWS, THURSTON, Minneapolis, Minn. City Feed Co., St. Albans. *Nokomo's Durum* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

WHEAT MIDDLINGS

AMENDT MILLING CO., Monroe, Mich. H. B. Parkhurst, North Troy. *Pure Amco Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

ANSTEAD & BURKE, Springfield, O. H. N. Gray, Cambridge. *Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

ATLAS FLOUR MILLS, Milwaukee, Wis. H. W. Myers & Son, Bennington. *Atlas Wheat Middlings* and ground screenings not exceeding the mill-run. (Unguarantied); contained *16.3* percent crude protein.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Fancy White Middlings.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Middlings.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

BAY STATE MILLING CO., Winona Minn. E. M. Bixby & Son, Poultney. *Winona Middlings.* Guaranteed to contain *18* percent crude protein, but failed by a little more than two percent to fulfill guaranty.

BILL, BELL & CO., Ogdensburg, N. Y. A. N. Washburn, Bethel. *Flour Middlings.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BILL, BELL & CO., Ogdensburg, N. Y. A. B. Kilbourne, Bristol. *Shorts.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CANNON VALLEY MILLING CO., ————. Geo. J. Stannard, Fair Haven. *Cannon Valley Middlings.* Guaranteed to contain *18.25* percent crude protein, but failed by nearly one percent to fulfill guaranty.

CATARACT CITY MILLING CO., Niagara Falls, N. Y. Geo. J. Stannard, Fair Haven. *Cataract City Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

G. L. CHRISTIAN, Minneapolis, Minn. Madden & Trumbull, White River Junction. *Poland Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

L. CHRISTIAN & CO., Minneapolis, Minn. A. N. Washburn, Bethel. *Matchless Standard Middlings.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. W. V. Phelps, Enosburg Falls. *Wirthmore Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DETROIT MILLING CO., Detroit, Mich. J. E. Hunt & Son, Jeffersonville. *Fancy Apex Middlings.* Guaranteed to contain *17* percent crude protein, but failed by one and one-quarter percent to fulfill guaranty.

DETROIT MILLING CO., Detroit, Mich. J. E. Hunt & Son, Jeffersonville. *Tiger Pure Middlings.* Guaranteed to contain *17* percent crude protein, but failed by a half percent to fulfill guaranty.

FEDERAL MILLING CO., Lockport, N. Y. T. C. Jennison, Sheldon; J. W. Gillis, Danville. *Lucky Spring Wheat Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. N. Washburn, Bethel; Mathews & Hall, Orleans; D. H. McHugh, Middlebury; Geo. Shorey, Lyndonville. *Dairy Maid Winter Wheat Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. D. Pease, Burlington. *Dairy Maid Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

GARDNER MILLS, ————. H. S. Buttles' Estate, Brandon. *Snowball White Middlings* and ground screenings not exceeding the mill-run. (Unguarantied); contained *17.1* percent crude protein.

GWINN MILLING Co., Columbus, O. Griswold & Mackinnon, St. Johnsbury. *Middlings*, with cleansed, ground wheat screenings not exceeding mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. Charlotte Feed Co., Charlotte. *Standard Middlings*, with mill-run screenings. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

LA GRANGE MILLS, Red Wing, Minn. Griswold & Mackinnon, St. Johnsbury. *La Grange Fine Middlings*. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., ————. Charlotte Feed Co., Charlotte. *Elmco Fancy White Middlings*. Guaranteed to contain *16.09* percent crude protein, but failed by nearly a half percent to fulfill guaranty.

NATIONAL MILLING Co., Toledo, O. Perley & Leavens, Cambridge; Clark & Davidson, Groton. *Middlings*. Guaranteed to contain *17.5* percent crude protein, but failed by one-quarter percent to fulfill guaranty.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. City Feed Co., St. Albans; F. P. Edgerton, Wallingford. *Choice Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Half Century Store Co., Randolph. *XXX Comet Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Mathews & Hall, Orleans; A. B. Kilbourne, Bristol. *Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. E. W. Bailey & Co., Swanton; F. M. Sherman & Co., Newport; F. A. Sheldon, Rupert. *Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Winnipeg, Man. E. T. & H. K. Ide, Fairlee; Richmond Lumber Co., Richmond. *O Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. Chas. M. Seaver, Williamstown; A. B. Kilbourne, Bristol. *Pillsbury's XX Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. L. L. Marsh, Enosburg Falls. *Flour Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. H. S. Buttles' Estate, Brandon; Clark & Devine, Northfield; Miles, McMahon & Son, Stowe; J. D. Thompson, Norwich. *Standard Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. C. C. Miller, Wells River. *Stott's Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. Charlotte Feed Co., Charlotte; H. C. Skeels & Co., Swanton. *Stott's Pennant Pure Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. C. W. Sherman Estate, W. Rupert. *Winter White Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. Geo. J. Stannard, Fair Haven; S. Sherman & Son, Inc., Poultney. *Angelus Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

TIOGA MILL & ELEVATOR Co., Waverly, N. Y. F. A. Sheldon, Rupert. *Waverly Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Madden & Trumbull, White River Junction. *Farmers' Favorite Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Gregory Grain Co., Burlington. *Farmers' Favorite Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. H. B. Parkhurst, North Troy. *Waumbeck Dairy Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. A. D. Pease, Burlington, *Waumbeck Dairy Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. A. B. Kilbourne, Bristol. *Crescent Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. E. W. Bailey & Co., Montpelier; E. R. Sheldon, Rupert. *Washburn-Crosby's Wheat Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *17* percent crude protein, but failed by more than a half percent to fulfill guaranty.

WASHBURN MILLS, Minneapolis, Minn. Sweat-Comings Co., Richford; E. I. Benson, Woodstock. *Washburn-Crosby's Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WHEAT MIXED FEEDS

ACME-EVANS Co., Indianapolis, Ind. Burditt Bros., Brandon. *Acme Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

AMENDT MILLING Co., Monroe, Mich. H. B. Parkhurst, North Troy. *Pure Amco Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

AMENDT MILLING Co., Monroe, Mich. Farmers' Exchange, Bradford. *Amco Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

E. W. BAILEY & Co., Montpelier, Vt. L. B. Jenne, Derby Center. *Bailey's Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by almost one percent to fulfill guaranty.

E. W. BAILEY & Co., Montpelier, Vt. Perley & Leavens, Cambridge; Chas. M. Seaver, Williamstown. *Bailey's Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BARBER MILLING Co., Minneapolis, Minn. W. F. Cunningham, St. Albans. *White Satin Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WM. A. COOMBES MILLING Co., Coldwater, Mich. E. E. Harris & Co., Morrisville. *Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. W. V. Phelps, Enosburg Falls; H. K. Foster, South Royalton. *Wirthmore Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

FEDERAL MILLING Co., Lockport, N. Y. J. E. Foster, Underhill. *Lucky Spring Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. C. O. Fuller, North Troy; R. L. Clark, Barre. *Dairy Maid Winter Wheat Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. Griswold & Mackinnon, St. Johnsbury; MacDiarmid & Co., Newport. *Xtra Good Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. J. E. Turnbull & Co., Orleans. *Creamery Mixed Feed.* Guaranteed to contain *15* percent crude protein, but failed by one percent to fulfill guaranty.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. E. Lane & Sons, Newport; E. I. Benson, Woodstock. *Hecker's Mixed Feed* with mill-run screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEHLOR FLOUR MILL Co., St. Louis, Mo. E. I. Benson, Woodstock. *Kehlor's Mill Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. A. H. McLeod Milling Co., St. Johnsbury; R. P. Webster, Barton; E. T. Seabury Estate, Waterbury. *Crescent Mixed Feed* and ground wheat screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

LAWRENCEBURG ROLLER MILLS Co., Lawrenceburg, Ind. H. A. Slayton & Co., Morrisville; D. H. McHugh, Middlebury. *Snowflake Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.2* percent crude protein; guaranty fulfilled.

A. H. MCLEOD MILLING Co., St. Johnsbury, Vt. C. W. Hartwell, Newbury; R. P. Webster, Barton. *Brooks' Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

A. H. MCLEOD MILLING Co., St. Johnsbury, Vt. H. B. Sturtevant, East Fairfield. *Sturtevant's Mixed Feed.* (Unguarantied); contained *14.7* percent crude protein.

NATIONAL MILLING Co., Toledo, O. E. W. Bailey & Co., Montpelier. *Osota Mixed Feed.* Guaranteed to contain *17* percent crude protein, but failed by almost two and one-half percent to fulfill guaranty.

NATIONAL MILLING Co., Toledo, O. A. B. Kilbourne, Bristol; J. D. Thompson, Norwich; H. K. Foster, South Royalton; E. W. Bailey & Co., Montpelier. *Osota Mixed Feed.* Guaranteed to contain *17* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

NATIONAL MILLING Co., Toledo, O. H. P. Munson Estate, Morrisville; J. D. Thompson, Norwich; Clark & Davidson, Groton. *Pennant Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NATIONAL MILLING Co., Toledo, O. Chas. M. Seaver, Williamstown. *Pennant Quality Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. Chas. M. Seaver, Williamstown. *Perfect Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Davis Feed Co., Rutland. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. F. M. Sherman, Newport. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. F. P. Edgerton, Wallingford. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. R. P. Webster & Son, Barton; Half Century Store Co., Randolph; Joyce & Marshall, West Burke. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGDENSBURG ROLLER MILLS, Ogdensburg, N. Y. C. O. Fowler, North Troy. *Winter Mixed Feed.* (Unguarantied); contained *14.5* percent crude protein.

PILLSBURY'S MILLS, Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury; A. B. Kilbourne, Bristol; E. T. Seabury Estate, Waterbury; H. E. Shaw, Stowe. *Fancy Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PILLSBURY Co., Minneapolis, Minn. L. L. Marsh, Enosburg Falls. *Pillsbury's Fancy Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman, Newport; A. N. Washburn, Bethel. *Champion Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.56* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. Miles, McMahon & Son, Stowe; L. L. Marsh, Enosburg Falls; E. W. Bailey & Co., Montpelier; L. G. Roundy, West Burke. *Occident Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

SHEFFIELD-KING MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Gold Mine Mixed Feed and Screenings.* Guaranteed to contain *15.9* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. E. T. & H. K. Ide, St. Johnsbury. *Try Me Winter* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. Richmond Lumber Co., Richmond. *Wabash Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. H. S. Buttles' Estate, Brandon. *Monarch Fancy Mixed Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein, but failed by three-quarters of a percent to fulfill guaranty.

F. W. STOCK & SONS, Hillsdale, Mich. Strong & Goddard, Hyde Park; D. H. McHugh, Middlebury. *Superior Mixed Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. B. PARKHURST, North Troy. *Stott's Honest Mixed Feed.* Guaranteed to contain *16.5* percent crude protein, but failed by one percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. B. Parkhurst, North Troy; H. S. Buttles' Estate, Brandon. *Stott's Heavy Pure Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

STRATTON & Co., Concord, N. H. A. H. Merrill Estate, Norwich. *Stratton's Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.87* percent crude protein; guaranty fulfilled.

ST. ALBANS GRAIN Co., St. Albans, Vt. City Feed Store, St. Albans. A. N. Washburn, Bethel. *Hygrade Mixed Feed* and screenings. Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

THOMPSON MILLING Co., Lockport, N. Y. W. F. Cunningham, St. Albans; S. Sherman & Son, Inc., Poultney. *Angelus Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Gregory Grain Co., Burlington. *Farmers' Favorite Cow Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.8* percent crude protein, but failed by nearly two percent to fulfill guaranty.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Miles, McMahon & Son, Stowe; E. E. Harris & Co., Morrisville; G. W. Marble, Woodstock. *Farmers' Favorite Cow Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.8* percent crude protein, but failed by one percent to fulfill guaranty.

VERMONT CEREAL Co., Burlington, Vt. H. B. Parkhurst, North Troy. J. W. Gillis, Danville. *Waumbeck Special Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. G. W. Rose, Middlebury. *Mill-run Bran Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. E. T. Seabury Estate, Waterbury. *Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

WILLIAMS BROS., Kent, O. J. D. Thompson, Norwich. *Kent Mixed Feed.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

RED DOG FLOUR

ATLAS FLOUR MILLS, Milwaukee, Wis. H. W. Myers & Son, Bennington. *Atlas.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Fancy.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

BAY STATE MILLING CO., Winona, Minn. E. M. Bixby & Son, Poultney. *G.* Guaranteed to contain *18* percent crude protein, but failed by a little more than two percent to fulfill guaranty.

EAGLE ROLLER MILL CO., New Ulm, Minn. G. W. Rose, Middlebury. *Superb.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

NATIONAL MILLING CO., Minneapolis, Minn. G. W. Rose, Middlebury. *Bob Fancy.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING CO., Niagara Falls, N. Y. City Feed Co., St. Albans. *Choice.* Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. A. H. McLeod Milling Co., St. Johnsbury; F. A. Sheldon, Rupert; F. M. Sherman & Co., Newport. *XXX Comet.* Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

OGDENSBURG ROLLER MILLS, Ogdensburg, N. Y. W. C. Marsh, Sheldon. ———. (Unguarantied); contained *14* percent crude protein.

PILLSBURY CO., Minneapolis, Minn. J. D. Thompson, Norwich; L. L. Marsh, Enosburg Falls. *XXX Daisy.* Guaranteed to contain *17* percent crude protein, but failed by a third of a percent to fulfill guaranty.

RUSSELL-MILLER MILLING CO., Minneapolis, Minn. H. S. Buttles' Estate, Brandon. ———. Guaranteed to contain *16* percent crude protein, but failed by nearly one-half percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. S. Buttles' Estate, Brandon. *Stag.* Guaranteed to contain *15* percent crude protein, but failed by two-thirds of a percent to fulfill guaranty.

WASHBURN-CROSBY CO., Minneapolis, Minn. C. W. Hartwell, Newbury. *Arlington.* (Unguarantied); contained *14.4* percent crude protein.

WASHBURN-CROSBY CO., Minneapolis, Minn. Walker & Brock, Barnet. *Goliath (Hecker).* (Unguarantied); contained *13.1* percent crude protein.

WASHBURN MILLS, Minneapolis, Minn. H. E. Shaw, Stowe; E. R. Sheldon, Rupert; Half Century Store Co., Randolph; E. T. & H. K. Ide, St. Johnsbury; Vermont Marble Co., Proctor. *Adrain.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

HOMINY FEEDS

AMERICAN HOMINY CO., Indianapolis, Ind. W. F. Cunningham, St. Albans; Chas. M. Seaver, Williamstown. *Homco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

AMERICAN HOMINY CO., Indianapolis, Ind. Cunningham Feed Co., St. Albans; E. Crosby & Co., Brattleboro. *Homco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BUFFALO CEREAL CO., Buffalo, N. Y. S. P. Carter & Son, Rutland. *Bufceco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. City Feed Store, St. Albans. *Wirthmore.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. City Feed Store, St. Albans. *Wirthmore.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

EAGLE ROLLER MILLING CO., New Ulm, Minn. Burditt Bros., Rutland. ———. Guaranteed to contain *10.37* percent crude protein, but failed by a quarter percent to fulfill guaranty.

EVANS MILLING Co., Indianapolis, Ind. A. D. Pease, Burlington. *Emco Evans.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PATENT CEREALS Co., Geneva, N. Y. E. M. Bixby & Son, Poultney. Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PLYMOUTH MILLING Co., ————. Burditt Bros., Brandon. *Plymouth's Pure.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. J. G. Turnbull & Co., Orleans. Griswold & Mackinnon, St. Johnsbury. *Yellow.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Burlington Flouring Co., Burlington; A. D. Pease, Burlington. *Yellow.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

M. G. RANKIN & Co., Milwaukee, Wis. E. W. Bailey & Co., Montpelier. *Jersey.* Guaranteed to contain *10* percent crude protein, but failed by a half percent to fulfill guaranty.

DRIED BEET PULPS

AMERICAN SUGAR Co., Saginaw, Mich. E. W. Bailey & Co., Montpelier. ————. (Unguarantied); contained *8.8* percent crude protein.

HOTTELET Co., Milwaukee, Wis. Griswold & Mackinnon, St. Johnsbury. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. E. W. Bailey & Co., Montpelier. Kempton Mills, Barre. J. D. Thompson, Norwich. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. Burlington Flouring Co., Burlington; E. Crosby & Co., Brattleboro. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

ALFALFA MEALS

DENVER ALFALFA MILLING & PRODUCTS Co., Hartman, Colo. E. W. Bailey & Co., Montpelier. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. Griswold & Mackinnon, St. Johnsbury. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. E. T. & H. K. Ide, St. Johnsbury. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

EMPIRE STATE MILLS, Morrisville, N. Y. S. P. Curtis & Son, Rutland. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

KORNFALFA FEED & MILLING Co., Kansas City, Mo. J. H. Hewitt, South Royalton. *Pioneer.* Guaranteed to contain *12* percent crude protein, but failed by one percent to fulfill guaranty.

KORNFALFA FEED & MILLING Co., Kansas City, Mo. J. W. Jones & Co., Burlington. *Pioneer.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

M. C. PETERS, Omaha, Neb. J. H. Hewitt, South Royalton. *Lucerne Pure.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

PURINA MILLS, St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

OTTO WEISS MILLING Co., Wichita, Kan. Burditt Bros., Rutland. ———— Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

————. E. Crosby & Co., Brattleboro. ————. (Unguarantied); contained *13.1* percent crude protein.

————. H. W. Myers & Son, Inc., Bennington. ————. (Unguarantied); contained *15.8* percent crude protein.

MISCELLANEOUS

E. W. BAILEY & Co., Montpelier, Vt. E. W. Bailey & Co., Montpelier. *Corn and Oats Provender.* Contained 10.1 percent crude protein.

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Mohawk Corn Meal.* Contained 8.3 percent crude protein.

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Ground White Oats.* Contained 12.3 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Corn Meal.* Contained 10.1 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Cracked Corn.* Contained 9.4 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Kafir.* Contained 10.8 percent crude protein.

H. N. GRAY, Cambridge, Vt. H. N. Gray, Cambridge. *Corn and Oats Provender.* Contained 10.8 percent crude protein.

M. C. Co., ————. Burlington Flouring Co., Burlington. *Wheat screenings.* Contained 12.1 percent crude protein.

W. R. WHITE, North Bennington, Vt. W. R. White, North Bennington. *Buckwheat Bran.* Contained 21.8 percent crude protein.

W. R. WHITE, North Bennington, Vt. W. R. White, North Bennington. *Buckwheat Middlings.* Contained 14.9 percent crude protein.

PROPRIETARY FEEDS

DAIRY, STOCK, HORSE

AMERICAN HOMINY Co., Indianapolis, Ind. E. A. Dutton, East Craftsbury; E. Crosby & Co., Brattleboro. *Homcoline Feed.* Ingredients as stated by manufacturer, "Corn germ meal." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. E. W. Bailey & Co., Montpelier. *Cream of Corn Dairy Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

ARCADY FARMS' MILLING Co., 208 South LaSalle St., Chicago, Ill. H. S. Buttles' Estate, Brandon. *Arcady Dairy Feed.* Ingredients as stated by manufacturer, "Malt sprouts, brewers' dried grains, cottonseed meal, molasses, oat by-products, ground grain screenings, salt." (Illegal label). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

ARCADY FARMS' MILLING Co., 208 South LaSalle St., Chicago, Ill. Chaffee Lumber Co., Rutland; Crosby Grain Store, South Londonderry. *Arcady Dairy Feed.* Ingredients as stated by manufacturer, "Malt sprouts, brewers' dried grains, cottonseed meal, molasses, oat by-products, ground grain screenings, salt." (Illegal label). Guaranteed to contain *16* percent crude protein, but failed by a quarter of one percent to fulfill guaranty.

E. W. BAILEY & Co., Swanton, Vt. E. W. Bailey & Co., Montpelier; R. P. Webster, Barton. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by one percent to fulfill guaranty.

E. W. BAILEY & Co., Swanton, Vt. E. W. Bailey & Co., Montpelier. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

E. W. BAILEY & Co., Montpelier, Vt. Clark & Devine, Northfield; L. L. Marsh, Enosburg Falls; E. I. Benson, Woodstock. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BOUTWELL MILLING & GRAIN Co., Troy, N. Y. G. W. Rose, Middlebury. *Boutwell's Rye Feed.* Ingredients as stated by manufacturer; not given.

(This is possibly an unmixed by-product from the manufacture of rye flour). Guaranteed to contain *12.5* percent crude protein; guaranty ful- percent to fulfill guaranty.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Dairy (No. 1) Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, old process linseed meal, dried brewers' grains, dried beet pulp, gluten feed, hominy, wheat middlings, wheat flour, wheat bran and salt." Guaranteed to contain *26* percent crude cent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Dairy (No. 3) Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, old process linseed meal, dried brewers' grains, dried beet pulp, gluten feed, hominy, wheat middlings, wheat flour, wheat bran and salt." Guaranteed to contain *22* percent crude guaranty.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Burlington Chop Feed.* Ingredients as stated by manufacturer, "Corn meal, rolled or ground oats, ground wheat and wheat screenings, hominy feed and reground oat feed." (Illegal label). Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. Griswold & Mackinnon, St. Johnsbury, Vt. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *28* percent crude protein, but failed by one and one-half percent to fulfill protein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. R. L. Clark, Barre; Davis Feed Co., Rutland; C. M. McFarland & Son, Barton; A. G. Spaulding, Ludlow. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *26* percent crude protein, but failed by a third of one percent to fulfill guaranty.

CHAPIN & Co., Hammond, Ind. D. H. McHugh, Middlebury; C. M. McFarland & Son, Barton; Chas. M. Seaver, Williamstown; J. D. Thompson, Norwich. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *26* per- protein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. J. E. Hunt & Co., Jeffersonville; E. I. Benson, Woodstock. *Lactola Dairy Feed.* Ingredients as stated by manufacturer, "Choice cottonseed meal, corn distillers' grains, clipped oat by-product, corn gluten feed, corn germ meal, brewers' dried grains, ivory nut meal, cane molasses, salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CITY FEED Co., St. Albans, Vt. City Feed Co., St. Albans. *Farmers' Favorite Ration Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, Buffalo gluten, malt sprouts, distillers' grains, bran, hominy or corn meal, linseed and salt not over 0.75 percent." Guaranteed to contain *25.5* percent crude protein; guaranty fulfilled.

CITY FEED Co., St. Albans, Vt. City Feed Co., St. Albans. *Farmers' Favorite Ration Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, Buffalo gluten, malt sprouts, distillers' grains, bran, hominy or corn meal, linseed and salt not over 0.75 percent." Guaranteed to contain *25.5* percent crude protein, but failed by nearly one and three-fourths filled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. C. E. Miller, Wells River; C. O. Fowler, North Troy; E. W. Bixby & Son, Poultney; H. E. Shaw, Stowe. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, cocoa shell meal,

clipped oat by-product, molasses and a small percentage of salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. Griswold & Mackinnon, St. Johnsbury; Jones & Berry, Montpelier; F. N. Sherman & Son, Newport. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, cocoa shell meal, clipped oat by-product, molasses and a small percentage of salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. C. M. McFarland, & Son, Barton. *Peerless Horse Feed.* Ingredients as stated by manufacturer, "Cracked corn, crushed oats, alfalfa meal, molasses and a small percentage of salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

COMMERCIAL MILLING Co., Detroit, Mich. Star Feed Store, Burlington. *Henkel's Chop Feed.* Ingredients as stated by manufacturer, "Corn meal, rye and oat middlings, oats and oat hulls." Guaranteed to contain *8.5* percent crude protein, but failed by about one-quarter of one percent to fulfill guaranty.

CORNO MILLS, St. Louis, Mo. F. P. Edgerton, Wallingford. *Corno Horse and Mule Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, ground corn, cottonseed meal, hominy feed, oat feed." (Illegal label). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. Mathews & Hall, Orleans; A. N. Washburn, Bethel. *Wirthmore Balanced Ration for Milch Cows.* Ingredients as stated by manufacturer, "Cottonseed meal, gluten feed, linseed meal, brewers' grains, malt sprouts, distillers' grains, bran, and hominy or corn meal, 0.75 percent salt." Guaranteed to contain *25.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. E. T. Seabury Estate, Waterbury; City Feed Co., St. Albans; G. W. Marble, Woodstock; Swerdfeger & Davis, Marshfield; R. L. Clark, Barre. *Wirthmore Stock Feed for Milch Cows.* Ingredients as stated by manufacturer, "Ground barley, ground oats, ground hominy meal, ground corn and oatmeal mill by-products (oat middlings, oat shorts and oat hulls) and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. Jones & Berry, Montpelier; Nelson Bros., Springfield; D. W. Paul, East Berkshire; H. I. Randall, Wolcott. *Wirthmore Stock Feed.* Ingredients as stated by manufacturer, "Ground barley, ground oats, ground hominy meal, ground corn and oatmeal mill by-products (oat middlings, oat shorts and oat hulls) and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. W. C. Ballou, Newfane. *Crosby's Ready Ration.* Ingredients as stated by manufacturer, "Distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

E. CROSBY & Co., Brattleboro, Vt. E. T. & H. K. Ide, St. Johnsbury. *Crosby's Ready Ration.* Ingredients as stated by manufacturer, "Distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. Farmers' Exchange, Bradford; E. H. Mason, Randolph; W. F. Cunningham, St. Albans; G. S. Welch, Groton. *Crosby's Special Stock Food.* Ingredients as stated by manufacturer, "Wheat middlings, corn meal, hominy feed, brewers' dried grains, oatmeal mill by-products (oat shorts, oat hulls, oat middlings) and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Quality Stock Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. C. E. Miller, Wells River. *Dewey's Ready Ration.* Ingredients as stated by manufacturer, "Eagle distillers' dried grains, linseed oil meal, cottonseed meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* crude protein, but failed by one-third of one percent to fulfill guaranty.

DEWEY BROS. Co., Blanchester, O. C. E. Miller, Wells River; F. D. Lapelle & Co., Swanton; E. T. Seabury Estate, Waterbury; Charlotte Feed Co., Charlotte. *Dewey's Ready Ration.* Ingredients as stated by manufacturer, "Eagle distillers' dried grains, linseed oil meal, cottonseed meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. Half Century Store Co., Randolph. *Dewey's Stock Feed.* Ingredients as stated by manufacturer, "Wheat feeds, rye middlings, oat meal, 0.5 percent salt." (Illegal). Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

ELMORE MILLING Co., Oneonta, N. Y. S. Sherman & Son, Inc., Poultney. *Elmore Milk Grains.* Ingredients as stated by manufacturer, "Corn distillers' dried grains, old process linseed meal, cottonseed meal, gluten feed, hominy meal, choice wheat bran, barley, malt sprouts, dried brewers' grains, a little fine table salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. H. Waite & Son, Morrisville. *Lucky Oat Corn Feed.* Ingredients as stated by manufacturer, "Half oats, half corn, hominy feed, crushed oats, cracked corn, corn feed meal." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

D. H. GRANDIN MILLING Co., Jamestown, N. Y. H. M. Brown, Castleton. *Grandin's Stock Feed.* Ingredients as stated by manufacturer, "Oats, corn, hominy feed, oat hulls, corn oil meal, gluten and salt." A varient of this statement reads "oats, corn, barley, barley middlings, hominy feed, oat hulls, salt." Guaranteed to contain *8.5* percent crude protein; guaranty fulfilled.

D. H. GRANDIN MILLING Co., Jamestown, N. Y. Davis Feed Co., Rutland. *Grandin's Stock Feed.* Ingredients as stated by manufacturer, "Oats, corn, hominy feed, oat hulls, corn oil meal, gluten and salt." A varient of this statement reads "oats, corn, barley, barley middlings, hominy feed, oat hulls, salt." Guaranteed to contain *8.5* percent crude protein, but failed by nearly a quarter of one percent to fulfill guaranty.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. Griswold & Mackinnon, St. Johnsbury. *Xtra Good Stock Feed.* Ingredients as stated by manufacturer, "Corn, barley, hominy feed, wheat flour, puffed rice and wheat, oat meal mill by-product (oat middlings, oat hulls, oat shorts), middlings with screenings not exceeding mill-run, cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. Guild Grain Co., Ludlow. *H. O. Co.'s Algrane Milk Feed.* Ingredients as stated by manufacturer. "Oat hulls, wheat middlings, gluten feed, corn, cottonseed meal, oats, oat shorts, salt." Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. Co.'s Algrane Horse Feed.* Ingredients as stated by manufacturer, "Oats, oat shorts, ground corn, oat hulls, middlings, hominy, gluten, molasses and 0.5 percent salt." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. New England Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, ground corn, hominy, oat meal, ground screenings, molasses and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. Co.'s De-Fi Feed.* Ingredients as stated by manufacturer, "Oat hulls, ground corn, hominy feed, wheat middlings, oat middlings, oat shorts, ground grain screenings, molasses and 0.5 percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

W. H. HASKELL & Co., Toledo, O. R. L. Clark, Barre. *Haskell's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground oats, hominy feed, oat hulls, oat shorts and salt." Guaranteed to contain *8* cent crude protein; guaranty fulfilled.

J. H. HEWITT, South Royalton, Vt. J. H. Hewitt, South Royalton. *Our Stock Feed.* Ingredients as stated by manufacturer, "Hominy and oat feed or regrounds." (Illegal label). Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

INTERNATIONAL SUGAR FEED Co., Minneapolis, Minn. J. E. Foster, Underhill; W. R. White, North Bennington. *International Special Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, molasses, ground recleaned grain screenings, ground clipped oat by-product, salt." (Illegal label). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. Burditt Bros., Ludlow; Burditt Bros., Rutland; C. S. Richmond, Northfield. *Larro-Feed-Ready Ration.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, dried distillers' grains (mainly from corn), dried beet pulp, standard wheat bran, standard wheat middlings and 0.75 percent salt. Wheat bran and wheat middlings may contain ground screenings not exceeding mill-run." Guaranteed to contain *20* percent crude protein, but failed by a little more than one-half of one percent to fulfill guaranty.

LARROWE MILLING Co., Detroit, Mich. Richmond & Son, Northfield; G. W. Rose, Middlebury. *Larro-Feed-Ready Ration.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, dried distillers' grains (mainly from corn), dried beet pulp, standard wheat bran, standard wheat middlings and 0.75 percent salt. Wheat bran and wheat middlings may contain ground screenings not exceeding mill-run." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

MAYFLOWER MILLS, Fort Wayne, Ind. Vermont Cereal Co., Burlington, Vt. Richmond & Son, Northfield; Frank Amsden, Greensboro Bend. *Waumbeck Milk Makers' Mixture.* Ingredients as stated by manufacturer, "Dried malted grains, old process oil meal, cottonseed meal, pulverized grain screenings, 0.5 percent salt added." Guaranteed to contain *23* per-percent crude protein; guaranty fulfilled.

R. H. MCEWEN MILLING Co., Ogdensburg, N. Y. John Burdick, Wallingford. *Pontiac Dairy Ration.* Ingredients as stated by manufacturer, "Distillers' dried grains, malt sprouts, hominy meal, cottonseed meal, linseed meal, wheat bran and 0.5 percent salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

NATIONAL OATS Co., St. Louis, Mo. F. C. Jennison, Sheldon. *Pawnee Cow Feed.* Ingredients as stated by manufacturer, "Hominy feed, cottonseed meal, ground grain screenings and oat feed." (Illegal label). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NOWAK MILLING CORPORATION, Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Justice Stock Feed.* Ingredients as stated by manufacturer, "Ground oats, corn feed meal, wheat middlings, oat middlings, oat hulls, clipped oat by-product, ground grain screenings, 0.75 percent salt." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by nearly 2 percent to fulfill guaranty.

NOWAK MILLING CORPORATION, Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Pure Mo-Lene Horse Feed.* Ingredients as stated by manufacturer, "Cracked corn, crushed oats, whole oats, ground alfalfa, molasses, 0.75 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

PILLIOD MILLING Co., Swanton, O. J. W. Gillis, Danville. *Waumbeck Butter-Fat Meal.* Ingredients as stated by manufacturer, "Cottonseed meal, old process oil meal, ground wheat, ground screenings." Guaranteed to

contain *24* percent crude protein, but failed by more than 4 percent to fulfill guaranty.

PURINA MILLS, Buffalo, N. Y. W. C. Marsh, Sheldon; H. A. Slayton & Co., Morrisville. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein, but failed by almost one and three-fourths percent to fulfill guaranty.

PURINA MILLS, Buffalo, N. Y. H. A. Slayton & Co., Morrisville. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

PURITY OATS CO., Davenport, Ia. A. G. Spaulding, Ludlow. *Iowa Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn meal, hominy feed, brewers' dried grains, oat meal mill by-product (oat shorts, oat hulls, oat middlings), and one percent table salt." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PURITY OATS CO., Davenport, Ia. Griswold & Mackinnon; J. G. Turnbull & Co., Orleans. *Iowa Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn middlings, hominy feed, brewers' dried grains, oat meal mill by-products (oat shorts, oat hulls, oat middlings), and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS CO., Davenport, Ia. Geo. J. Stannard, Fair Haven; Griswold & Mackinnon, St. Johnsbury. *Iowa Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn middlings, hominy feed, brewers' dried grains, oat meal mill by-products (oat shorts, oat hulls, oat middlings) and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS CO., Davenport, Ia. Clark & Devine, Northfield. *Purity Oat Feed.* Ingredients not stated by manufacturer. Illegal. Guaranteed to contain *6.73* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. Geo. Shorey, Lyndonville; Half Century Store Co., Randolph. *Blue Ribbon Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, malt sprouts, molasses, hominy, new process linseed oil meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts), bran with screenings not exceeding the mill-run." Guaranteed to contain *25* percent crude protein, but failed by nearly one and one-half percent to fulfill guaranty.

QUAKER OATS CO., Chicago, Ill. J. E. Hunt & Son, Jeffersonville. *Quaker Dairy Feed.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. J. R. Madigan, Burlington. *Quaker Dairy Feed.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

QUAKER OATS CO., Chicago, Ill. S. Sherman & Son, Poultney. *Quaker Dairy Feed with Molasses.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein, but failed by more than one-half of one percent to fulfill guaranty.

QUAKER OATS CO., Chicago, Ill. S. P. Curtis & Son, Rutland. *Green Cross Horse Mixed Feed.* Ingredients as stated by manufacturer, "Alfalfa meal, ground corn, crushed oats, molasses, cottonseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *10* percent crude protein, but failed by one-half of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. D. H. McHugh, Middlebury. *Green Cross Horse Mixed Feed.* Ingredients as stated by manufacturer, "Alfalfa meal, ground corn, crushed oats, molasses, cottonseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *10* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. City Feed Co., St. Albans; Miles, McMahon & Son, Stowe; A. B. Kilbourne, Bristol; E. T. & H. K. Ide, St. Johnsbury. *Schumaker's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground barley, hominy feed, wheat flour, wheat middlings with screenings, ground puffed rice, oatmeal mill by-product (oat middlings, hulls, shorts), cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. E. W. Bailey & Co., Montpelier; E. Crosby & Co., Brattleboro; E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman & Son, Newport. *Schumaker's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground barley, hominy feed, wheat flour, wheat middlings with screenings, ground puffed rice, oatmeal mill by-product (oat middlings, hulls, shorts), cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Richford, Vt. L. L. Marsh, Enosburg Falls. *White Diamond Feed.* Ingredients as stated by manufacturer, "Ground corn, hominy feed, oatmeal mill by-products (oat middlings, oat hulls, oat shorts), and 0.5 percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. G. W. Rose, Middlebury; G. W. Marble, Woodstock; R. P. Webster, Barton. *Purina Cow-Chow Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, gluten feed, brewers' dried grains, molasses, ground alfalfa and one percent salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. H. A. Slayton & Co., Morrisville; A. H. McLeod Milling Co., St. Johnsbury. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. J. W. Jones Co., Burlington; R. P. Webster, Barton; Jones & Berry, Montpelier. *Purina Feed with Molasses.* Ingredients as stated by manufacturer, "Cracked corn, whole oats, ground alfalfa, molasses and one percent salt." Guaranteed to contain *9.3* percent crude protein, but failed by a quarter of one percent to fulfill guaranty.

RALSTON-PURINA Co., INC., Buffalo, N. Y. H. A. Slayton & Co., Morrisville; R. L. Clark, Barre. *Purina Feed with Molasses.* Ingredients as stated by manufacturer, "Cracked corn, whole oats, ground alfalfa, molasses and one percent salt." Guaranteed to contain *9.3* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Jones & Berry, Montpelier; R. P. Webster, Barton. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., INC., Buffalo, N. Y. A. H. McLeod Milling Co., St. Johnsbury. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., INC., Buffalo, N. Y. Burditt Bros., Brandon. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

REPUBLIC MILLING Co., East St. Louis, Ill. J. D. Thompson, Norwich. *Supreme Horse Feed.* Ingredients as stated by manufacturer, "Corn, oats, alfalfa, cane molasses, salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

ROBIN HOOD MILLS, LTD., Moosejaw and Calgary, Alberta. F. D. Lapelle & Co., Swanton; Walker & Brock, Barnet. *Oat Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *5.25* percent crude protein; guaranty fulfilled.

DAVID STOTT MILLING Co., Detroit, Mich. H. C. Skeels & Co., Swanton. *Winner Chop Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. S. Sherman & Son, Inc., Poultney. *Elmore Stock Feed.* Ingredients as stated by manufacturer, "Corn meal, hominy, dried brewers' grains, wheat bran, oatmeal mill by-product (oat middlings, oat shorts, oat hulls), salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

UBIKO MILLING Co., Cincinnati, O. E. W. Bailey & Co., Montpelier; Burditt Bros., Ludlow; S. P. Curtis & Son, Rutland; A. H. McLeod Milling Co., St. Johnsbury; F. M. Sherman & Son, Newport. *Union Grains; Biles' Ready Ration.* Ingredients as stated by manufacturer, "Fourex distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, brewers' dried grains, barley malt sprouts, 0.5 percent fine table salt and nothing else." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

UBIKO MILLING Co., Cincinnati, O. Chas. M. Seaver, Williamstown; Miles, McMahon & Son, Stowe; L. L. Marsh, Enosburg Falls; E. T. & H. K. Ide, St. Johnsbury; A. B. Kilbourne, Bristol. *Union Grains; Biles' Ready Ration.* Ingredients as stated by manufacturer, "Fourex distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, brewers' dried grains, barley malt sprouts, 0.5 percent fine table salt and nothing else." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. Gregory Grain Co., Burlington. *Waumbeck Stable Feed.* Ingredients as stated by manufacturer, "Corn meal, rye and oat middlings, oats and oat hulls." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

R. P. WEBSTER, Barton, Vt. R. P. Webster, Barton. *Ray's Ready Ration.* Ingredients as stated by manufacturer, "Distillers' grain, bran, malt sprouts, gluten, cottonseed meal, molasses feed, linseed oil meal, 0.5 percent salt." (Illegal label). Guaranteed to contain *25* percent crude protein, but failed by nearly one percent to fulfill guaranty.

WESTERN GRAIN PRODUCTS Co., Hammond, Ind. City Feed Co., St. Albans, Vt. E. T. & H. K. Ide, St. Johnsbury. *Hammond Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn distillers' grains, malt sprouts, ground clipped oat by-product, ground grain screenings, molasses and salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

WESTERN GRAIN PRODUCTS Co., Hammond, Ind. E. T. & H. K. Ide, St. Johnsbury; MacDiarmid & Co., Newport. *Hammond Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn distillers' grains, malt sprouts, ground clipped oat by-product, ground grain screenings, molasses and salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

XTRA VIM MOLASSES FEED Co., Boston, Mass. R. L. Clark, Barre; L. L. Marsh, Enosburg Falls. *Xtra Vim Molasses Feed.* Ingredients as stated by manufacturer, "Pure cane sugar molasses, mixed with a small percentage of sphagnum moss." Guaranteed to contain *4.61* percent crude protein, but failed by a half of one percent to fulfill guaranty.

XTRA VIM MOLASSES FEED Co., Boston, Mass. A. B. Kilbourne, Bristol; Sweat-Comings Co., Richford; R. L. Clark, Barre. *Xtra Vim Molasses Feed.* Ingredients as stated by manufacturer, "Pure cane sugar molasses, mixed with a small percentage of sphagnum moss." Guaranteed to contain *4.61* percent crude protein; guaranty fulfilled.

PROPRIETARY FEEDS

CALF

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. Kempton Mills, Barre; E. R. Sheldon, Rupert; A. H. McLeod Milling Co., St. Johnsbury; F. D. Lapelle & Co., Swanton. *Blatchford's.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, barley meal, ground beans and peas, rice polish, old process oil meal, cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. John Burdick, Wallingford; E. W. Bailey & Co., Montpelier; H. Sturtevant, E. Fairfield. *Blatchford's.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, barley meal, ground beans and peas, rice polish, old process oil meal, cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt." Guaranted to contain *24* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. W. V. Phelps, Enosburg Falls. *Schumaker's.* Ingredients as stated by manufacturer, "Oatmeal, wheat meal, dried casein, ground flaxseed, cottonseed meal and not to exceed *0.5* percent bicarbonate of soda." Guaranteed to contain *19* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. C. M. McFarland & Son, Barton. *Schumaker's.* Ingredients as stated by manufacturer, "Oatmeal, wheat meal, dried casein, ground flaxseed, cottonseed meal and not to exceed 0.5 percent bicarbonate of soda." Guaranteed to contain *19* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

RYDE & Co., Chicago, Ill. Mathews & Hall, Orleans. *Ryde's Cream.* Ingredients as stated by manufacturer, "Fenugreek, anise seed, cottonseed meal, wheat flour, flaxseed meal, carob beans, bean meal, lentils, cocoa shells and salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

RYDE & Co., Chicago, Ill. Bradford Mills, Bradford. *Ryde's Cream.* Ingredients as stated by manufacturer, "Fenugreek, anise seed, cottonseed meal, wheat flour, flaxseed meal, carob beans, bean meal, lentils, cocoa shells and salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

PROPRIETARY FEEDS

POULTRY

ANIMAL MEAL, MEAT SCRAPS, ETC.

BEACH SOAP Co., Lawrence, Mass. Half Century Store Co., Randolph. *Star Bone and Meat Meal.* Ingredients as stated by manufacturer, "Bone and meat meal." Guaranteed to contain — percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. E. T. Seabury Estate, Waterbury; Mathews & Hall, Orleans. *Ground Beef Scraps.* Ingredients as stated by manufacturer, "Ground beef scraps." Guaranteed to contain *48* percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. E. T. Seabury Estate, Waterbury. *Ground Beef Scraps.* Ingredients as stated by manufacturer, "Ground beef scraps." Guaranteed to contain *48* percent crude protein, but failed by three and one-half percent to fulfill guaranty.

BURLINGTON RENDERING Co., Burlington, Vt. Chas. M. Seaver, Williamstown; E. T. & H. K. Ide, Bradford; Half Century Store Co., Randolph; W. R. White, N. Bennington. *Burlington Poultry Food.* Ingredients as stated by manufacturer, "Cooked meat and bone scraps." Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

BURLINGTON RENDERING CO., Burlington, Vt. Bradford Mills, Bradford; S. P. Curtis & Son, Rutland. *Burlington Poultry Food.* Ingredients as stated by manufacturer, "Cooked meat and bone scraps." Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

BURLINGTON RENDERING CO., Burlington, Vt. A. M. Washburn, Bethel. *Cracked Bone.* Ingredients as stated by manufacturer, "Cracked bone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

INTERNATIONAL GLUE CO., Boston, Mass. L. L. Marsh, Enosburg Falls; E. T. & H. K. Ide, St. Johnsbury. *Red Star Fish Scraps.* Ingredients as stated by manufacturer. Not stated. Illegal. Guaranteed to contain *45* percent crude protein, but failed by three and one-fourth percent to fulfill guaranty.

WHITMAN & PRATT RENDERING CO., Lowell, Mass. Griswold & Mackinnon, St. Johnsbury. *Whitman & Pratt Beef Scraps.* Ingredients as stated by the manufacturer, "Beef scraps." Guaranteed to contain *45* percent crude protein; guaranty fulfilled.

MASHES

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. J. E. Foster, Underhill. *Blatchford's Milk Mash.* Ingredients as stated by manufacturer, "Locust bean meal, flaxseed, wheat flour, barley meal, blood flour, ground beans and peas, rice polish, old process linseed meal, cocoa shell meal, cocoanut meal, cottonseed meal, fenugreek, dried milk, anise and salt, bone, corn and oatmeal middlings, beef scraps, fish and powdered limestone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. S. P. Curtis & Son, Rutland. *Blatchford's Milk Mash.* Ingredients as stated by manufacturer, "Locust bean meal, flaxseed, wheat flour, barley meal, blood flour, ground beans and peas, rice polish, old process linseed meal, cocoa shell meal, cocoanut meal, cottonseed meal, fenugreek, dried milk, anise and salt, bone, corn and oat meal middlings, beef scraps, fish and powdered limestone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. E. T. Seabury Estate, Waterbury. *Blatchford's Fill the Basket Egg Mash.* Ingredients as stated by manufacturer, "Bean, cocoanut, cottonseed, flaxseed, locust bran, linseed oil and pea meals, fenugreek, wheat flour, dried milk, cocoa shells, salt, alfalfa, barley, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum and limestone grit." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. S. P. Curtis & Son, Rutland. *Blatchford's Fill the Basket Egg Mash.* Ingredients as stated by manufacturer, "Bean, cocoanut, cottonseed, flaxseed, locust bran, linseed oil and pea meals, fenugreek, wheat flour, dried milk, cocoa shells, salt, alfalfa, barley, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum and limestone grit." Guaranteed to contain *19* percent crude protein; guaranty maintained.

BUFFALO CEREAL CO., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Bufceco Laying Mash.* Ingredients as stated by manufacturer, "Ground corn, oats, wheat and kafir corn, wheat bran, wheat middlings, linseed meal, alfalfa meal, oat middlings, meat and bone scraps and 0.5 percent salt." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. Mathews & Hall, Orleans; Geo. Shorey, Lyndonville. *Wirthmore.* Ingredients as stated by manufacturer, "Ground oats, ground barley, gluten feed, alfalfa meal, wheat bran, ground corn, wheat middlings and about 0.75 percent salt." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. R. L. Clark, Barre. *Wirthmore.* Ingredients as stated by manufacturer, "Ground oats, ground barley, gluten feed, alfalfa meal, wheat bran, ground corn, wheat middlings and about 0.75 percent salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

GREENE CHICK FEED Co., Marlboro, Mass. R. P. Webster, Barton. *Greene's Five Percent Meat Mash.* Ingredients as stated by manufacturer, "Meat scraps, corn meal, wheat, shell lime, hominy feed, flax screenings, oats, bran, salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

J. H. HEWITT, South Royalton, Vt. J. H. Hewitt, South Royalton. *Our Dry Mash.* Ingredients as stated by manufacturer, "Corn meal, gluten, wheat middlings, wheat bran, linseed meal, alfalfa meal and beef scraps." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

B. F. HENRY, North Bennington, Vt. B. F. Henry, North Bennington. *Henry's Mash.* Ingredients as stated by manufacturer, "Beef scraps, alfalfa, gluten feed, wheat bran and wheat middlings, corn meal, ground oats, charcoal, salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

A. B. KILBOURNE, Bristol, Vt. A. B. Kilbourne, Bristol. *Dry Mash.* Ingredients as stated by manufacturer, "Alfalfa meal, corn meal, ground oats, wheat bran, wheat middlings, gluten feed, linseed oil meal, meat scraps." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. I. Benson, Woodstock; Chas. M. Seaver, Williamstown; J. E. Foster, Underhill; G. W. Rose, Middlebury. *Lay or Bust Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn, wheat, oats, barley, kafir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp and salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Charlotte Feed Co., Charlotte; R. P. Webster, Barton. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meat, charcoal, not over one percent salt." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Burditt Bros., Rutland, H. A. Slayton & Co., Morrisville. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meat, charcoal, not over one percent salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meal, not over one percent salt." Guaranteed to contain *12* percent crude protein, but failed by a third of one percent to fulfill guaranty.

RALSTON-PURINA Co., St. Louis, Mo. Charlotte Feed Co., Charlotte. *Purina Chick Feed.* Ingredients as stated by manufacturer, "Wheat, corn, millet, kafir maize." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

W. R. WHITE, North Bennington, Vt. W. R. White, North Bennington. *Flynn's Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn meal, ground oats, old process oil meal, gluten, alfalfa, cooked meal or scraps, salt and charcoal." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

SCRATCH FEEDS

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. Iroquois. Ingredients as stated by manufacturer, "Corn, oat, barley, buckwheat, kafir corn, wheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. E. T. Seabury Estate, Waterbury; Mathews & Hall, Orleans. *Wirthmore.* Ingredients as stated by manufacturer, "Wheat, kafir corn, sunflower seed, buckwheat, cracked corn, barley, milo maize, oats." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Pure.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. A. H. McLeod Milling Co., St. Johnsbury. *Globe.* Ingredients as stated by manufacturer, "Corn, wheat,

barley, oats, kafir corn, buckwheat, sunflower, linseed oil cake." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. H. B. Sturtevant, East Fairfield. *Pine Tree.* Ingredients as stated by manufacturer, "Corn, wheat, buckwheat, barley, oats, kafir corn, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. O. Co. MILLS, Buffalo, N. Y. Guild Grain Store, Ludlow. *H. O. Co.'s Algrane.* Ingredients as stated by manufacturer, "Wheat, oats, kafir corn, buckwheat, wheat screenings, cracked corn, milo maize, sunflower seed, hulled oats, cracked peas, barley." Guaranteed to contain *11* percent crude protein, but failed by half of one percent to fulfill guaranty.

B. T. HENRY, North Bennington, Vt. B. T. Henry, North Bennington. *Henry's.* Ingredients as stated by manufacturer, "Cracked corn, wheat, oats, buckwheat, barley, kafir corn." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. E. T. & H. K. Ide, Bradford; G. S. Welch, Groton. *Ideal.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir corn, oats, buckwheat, barley, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. Bradford Mills, Bradford. *Ideal.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir corn, oats, buckwheat, barley, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

A. B. KILBOURNE, Bristol, Vt. A. B. Kilbourne, Bristol. ————. Ingredients as stated by manufacturer, "Cracked corn, oats, barley, wheat, buckwheat, charcoal and India wheat." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. W. MYERS & SON, INC., Bennington, Vt. H. W. Myers & Son, Inc., Bennington. *Green Mountain.* Ingredients as stated by manufacturer, "Cracked corn, wheat, oats, buckwheat, kafir corn, barley and sunflower seed." (Unguarantied). Contained 10.5 percent crude protein.

OSWEGO MILLING Co., Oswego, N. Y. F. D. Lapelle & Co., Swanton. *Pontiac.* Ingredients as stated by manufacturer, "Cracked corn, wheat, barley, buckwheat, oats, kafir corn and milo." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. Clark & Devine, Northfield; F. D. Lapelle & Co., Swanton. *Red Ribbon.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, kafir corn, oats, milo, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. I. Benson, Woodstock; Chas. M. Seaver, Williamstown. *Screened.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, oats, kafir corn, milo and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. I. H. Carr, Hardwick. *Iowa.* Ingredients as stated by manufacturer, "Cracked corn, wheat, hulled oats, kafir corn, milo maize, barley, recleaned wheat screenings, buckwheat and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. MacDiarmid & Co., Newport; Griswold & Mackinnon, St. Johnsbury. *Tom Boy.* Ingredients as stated by manufacturer, "Cracked corn, wheat, hulled oats, kafir corn or milo maize, barley, recleaned wheat screenings, buckwheat and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Richmond Lumber Co., Richmond; C. O. Fowler, North Troy. *Quaker.* Ingredients as stated by manufacturer, "Whole wheat, kafir corn, barley, cracked corn, buckwheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Bradford Mills, Bradford; A. D. Pease, Burlington. *Quaker.* Ingredients as stated by manufacturer, "Whole wheat, kafir corn, barley, cracked corn, buckwheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Sweat-Comings Co., Richford. *Schumaker's.* Ingredients as stated by manufacturer, "Whole wheat, whole kafir corn, whole barley, cracked Indian corn, whole buckwheat, sunflower seeds." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. A. D. Pease, Burlington. *Schumaker's.* Ingredients as stated by manufacturer, "Whole wheat, whole kafir corn, whole barley, cracked Indian corn, whole buckwheat, sunflower seeds." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURINA MILLS, St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. *Purina.* Ingredients as stated by manufacturer, "Wheat, corn, barley, kafir corn, milo maize, sunflower and buckwheat." Guaranteed to contain *11* percent crude protein, but failed by one percent to fulfill guaranty.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. H. A. Slayton & Co., Morrisville; A. H. McLeod Milling Co., St. Johnsbury. *Purina.* Ingredients as stated by manufacturer, "Wheat, corn, barley, kafir corn, milo maize, sunflower and buckwheat." Guaranteed to contain *11* percent crude protein, but failed by a half of one percent to fulfill guaranty.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. *Protena.* Ingredients as stated by manufacturer, "Wheat, corn, barley, sunflower, kafir corn, milo maize, recleaned grain screenings." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. *Winner.* Ingredients as stated by manufacturer, "Wheat, corn, barley, sunflower seed, kafir corn or milo maize, recleaned wheat screenings." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. "Griswold & Mackinnon, St. Johnsbury, R. L. Clark, Barre. *Wirthmore Growing Feed.* Ingredients as stated by manufacturer, "Wheat, corn, oats, barley, peas, milo, dried beet pulp, beef scraps, salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

MORRIS BROS., Oneonta, N. Y. E. M. Bixby & Son, Poultney. *Royal Brand Poultry Grains.* Ingredients as stated by manufacturer, "Cracked corn, kafir corn, buckwheat, wheat, oats." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CARROLL S. PAGE, Hyde Park, Vt. Bradford Mills, Bradford. *Page's Perfected Poultry Food.* Ingredients not stated by manufacturer. (Illegal). Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. *P. & P. Growing Feed.* Ingredients as stated by manufacturer, "Ground corn, wheat, barley, oats, meat, bone, alfalfa, kafir corn, wheat bran, wheat middlings, buckwheat, beet pulp, calcium carbonate and salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. F. D. Lapelle & Co., Swanton. *Intermediate Chick feed.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, oats, millet, kafir corn and milo." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. L. L. Marsh, Enosburg Falls. *Red Ribbon Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, cracked wheat, cracked oats, kafir corn, milo maize and whole millet seed." Guaranteed to contain *10* percent crude protein; guaranteed fulfilled.

PARK & POLLARD Co., Boston, Mass. F. D. Lapelle & Co., Swanton. *Margaret Mahaney's Turkey Feed.* Ingredients as stated by manufacturer, "Ground wheat, barley, linseed oil meal, oats, meat, bone, calcium hydroxide, calcium carbonate and salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. Half Century Store Co., Randolph. *Champion Chicken Wheat.* (Unguarantied). Contained 10.9 percent crude protein.

QUAKER OATS Co., Chicago, Ill. Bradford Mills, Bradford. *Quaker Chick Feed.* Ingredients as stated by manufacturer, "Cracked wheat, cracked kafir corn, cracked Indian corn, whole millet seed, oat meal, one percent

charcoal, wild buckwheat with not to exceed 0.5 percent foul seed. Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. S. P. Curtis & Son, Rutland. *Schumaker Little Chick Feed.* Ingredients as stated by manufacturer, "Cracked wheat, cracked kafir corn, cracked Indian corn, millet, oat meal, wild buckwheat, 0.5 percent wild seed, charcoal, marble grit." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. Burditt Bros., Rutland. *Purina Chick Feed.* Ingredients as stated by manufacturer, "Wheat, corn, millet, kafir maize." Guaranteed to contain *11* percent crude protein, but failed by more than one percent to fulfill guaranty.

ROBIN HOOD MILLS, LTD., Moose Jaw and Calgary, Alberta. F. D. Lapelle & Co., Swanton. *Groatlet's Chicken Feed.* Shelled oats. (Unguarantied). Contained 13.8 percent crude protein.

DISCUSSION OF THE RESULTS OF INSPECTION

There were taken 75 samples of the high protein manufacturing by-products (cottonseed, linseed and gluten meals, gluten feeds, distillers' and brewers' dried grains), 37 samples of low protein manufacturing products other than wheat offals (hominy feed, dried beet pulp, alfalfa meal, etc.), 158 samples of wheat offals (brans, middlings, mixed feeds, red dog flour) and 155 samples of proprietary brands, ready mixed rations for horses, cattle and poultry.

It was said in the 1915 bulletin dealing with feeding stuffs inspection that "the character of the feeds sold during the past winter has been excellent. At no time in the 16 years during which the feeding stuff inspection system has been in operation, has so favorable an outcome been secured. Only 12 of 396 samples of goods actually guarantied were deficient; and only 8 of the 12 deficients were one percent short, only 3 were two percent short and there was but a single serious deficiency. * * * * The situation appears to be thoroughly satisfactory so far as the guaranty maintenance is concerned."

The writer regrets that he is not able to announce as satisfactory a result this year or to be so optimistic as to the quality of the feeds farmers have bought in 1916. The outcome has been a distinctly disappointing one. A larger proportion of the feeding stuffs than usual has failed to measure up to the promises made in their behalf. The following tabulation sets forth the situation in concise form; and the annexed discussion goes into details.

	Number of analytical samples	Number of different brands	Protein guaranties range from	Protein contents range from	Guaranty fulfilled within tolerance figures	Guaranty not fulfilled	Unguaranteed
Cottonseed meals	28	16	41 to 37.8	42.5 to 35.8	14	14	..
Linseed meals	12	7	38 to 30	38.8 to 29.8	12	..	..
Gluten meals	1	1	40	47	1	..	..
Gluten feeds	14	9	24 to 23	28.1 to 22.6	14	..	..
Distillers' dried grains.	14	7	31 to 26	33.6 to 26.5	11	3	..
Brewers' dried grains..	6	4	27.2 to 19	30.1 to 17.4	4	2	..
Wheat offals	158	146	18.2 to 11	19.2 to 11.8	123	27	8
Wheat brans	52	50	16.5 to 11	18.4 to 11.8	47	4	1
Wheat middlings	44	41	18.2 to 13	17.8 to 14.6	36	6	2
Wheat mixed feeds..	48	41	17 to 12	19.2 to 14.5	34	12	2
Red dog flour	14	14	17 to 15	17.8 to 13.1	6	5	3
Hominy feeds	12	9	10.4 to 9	11.8 to 9.4	11	1	..
Dried beet pulps	4	3	8	9.2 to 8.8	3	..	1
Alfalfa meals	11	9	14 to 12	18.6 to 10.9	8	1	2
Miscellaneous	10	10			..	..	..
Proprietary feeds	155	116	48 to 4.6	45.8 to 4.1	127	24	4
Dairy, horse, stock..	88	62	26 to 4.6	28.8 to 4.1	69	18	1
High protein	23	17	26 to 20	28.8 to 19.4	17	6	..
Medium protein	18	10	19 to 16	22.1 to 14.5	14	4	..
Low protein	47	35	14 to 4.6	14.9 to 4.1	38	8	1
Calf meals	6	3	25 to 19	27.4 to 18.6	6	..	..
Poultry	61	51	48 to 9	45.8 to 9.6	52	6	3
Animal meals	8	6	48 to 20	45.8 to 25.4	6	2	..
Mashes	16	13	20 to 11	23.9 to 11.6	16	..	..
Scratch feeds	24	20	11 to 9	11.6 to 10.1	20	3	1
Chick feeds, etc...	13	12	24 to 10	24.6 to 9.6	10	1	2
Totals	425	337			328	72	15

The situation is yet more concisely set forth as follows:

Cottonseed meals. Half the cottonseed meal samples were not what they were represented to be in respect to their protein contents.

Dried distillers' grains. A fifth of the distillers' dried grains were similarly deficient.

Brewers' dried grains. A third of the brewers' dried grains were similarly deficient.

Wheat feeds. One-sixth of the wheat feeds were not as good as they were said to be in protein, the so-called "mixed feeds" and low grade or red dog feeding flour being particularly deficient.

Proprietary feeds. (*Dairy, horse, stock*). One-fifth of the brands were lacking in protein, poorer than they were said to be by their manufacturers.

Proprietary feeds. (*Poultry*). One-tenth of the brands were lacking in protein, poorer than they were said to be by their manufacturers.

The grand total. One in six of the brands offered for sale in the winter of 1915-16 was short of its protein promise. This is the worst outcome since the law has been on our statute books. Vermont buyers of feeds have been paying higher prices than heretofore and getting poorer goods.

In the following cases divergence between protein promise and fulfillment seems to be excessive.

F. W. Brodé & Co., Memphis, Tenn.
Owl Cottonseed Meal.....Guaranty 41%. Analysis 37.7%.
Owl Cottonseed Meal.....Guaranty 41%. Analysis 36.1%.

Humphreys, Godwin Co., Memphis, Tenn.
Bull Brand Cottonseed Meal..Guaranty 41%. Analysis 37.4%.

C. L. Montgomery & Co., Memphis, Tenn.
Canary Brand Cottonseed Meal,
Guaranty 38.63%. Analysis 35.7%.

J. E. Soper Co., Boston, Mass.
Pioneer Brand Cottonseed Meal,
Guaranty 41%. Analysis 37.9%.

Ajax Milling & Feed Co., New York, N. Y.
Ajax Flakes .....Guaranty 30%. Analysis 28.4%.

Ubiko Milling Co., Cincinnati, O.
Fourex Distillers' Grains.....Guaranty 30%. Analysis 28.2%.

Atlantic Export Co., Chicago, Ill.
Brewers' Dried Grains.....Guaranty 25%. Analysis 21.3%.

Fleischmann Co., Chicago, Ill.
Fleischmann's Brewers' Dried Grains,
Guaranty 19%. Analysis 17.4%.

Kornfalfa Feed Milling Co., Kansas City, Mo.
Pioneer Alfalfa Meal.....Guaranty 12%. Analysis 10.9%.

Pilloid Milling Co., Swanton, O.
Waumbeck Butter Fat Meal..Guaranty 24%. Analysis 19.8%.

City Feed Co., St. Albans, Vt.
Farmers' Favorite Ration Feed,
Guaranty 25.5%. Analysis 23.8%.

Ralston-Purina Co., St. Louis, Mo.
Protena Dairy Feed.....Guaranty 16.5%. Analysis 14.8%.

Quaker Oats Co., Chicago, Ill.
Quaker Dairy Feed.....Guaranty 16%. Analysis 14.5%.

E. W. Bailey & Co., Montpelier, Vt.
Yellow Tag Pennant Stock Feed..Guaranty 10%. Analysis 9%.

Nowak Milling Corp., Buffalo, N. Y.

Justice Stock Feed.....Guaranty 10%. Analysis 8.1%.

There were eight wheat offals which failed by large margins to meet their maker's guaranties. The facts are set forth in the tables on pages 17 to 25. In view of the fact that the Vermont law does not require these feeds to be guarantied it seems inadvisable specially to mention them at this point.

CONCERNING THE READY MIXED GOODS

These goods are widely advertised and widely used. Many of them are made from standard feeding stuffs; many contain material of low feeding value. Each package proclaims its contents, so that he who runs may read—if he will.

Let us next compare the prices of the different sorts sold for the feeding of cattle, horses, etc.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price
High protein	23	20 to 26	24	$34 50
Medium protein	18	16 to 19	17½	29 00
Low protein	47	4.6 to 14	10½	32 00

There is obviously no relationship between protein content and selling price; and he who needs protein to balance his farm grown grains and roughages need not be deterred by price in choosing the high rather than the low grades.

Let us next compare the prices of the different sorts sold for the feeding of poultry.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	1916 ± 1915
Meat meals	8	20 to 48	40	$57	—$1
Mashes	16	11 to 20	15	44	—$1
Scratch feeds	24	9 to 11	10	42	+ 0
Chick, etc., feeds.	13	10 to 24	14	44	— 3

Let us finally note the following statement of average guaranties and selling prices of concentrates which may prove of interest in this connection.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	1916 ± 1915
High protein, 20-40%					
Cottonseed meal	28	38-41	39	$38	+$4
Linseed meal	12	30-38	34	42	+ 2
Gluten meal	1	40	40	38	0
Gluten feed	14	23-24	24	33	— 1
Distillers' dried grains	14	26-31	29	35	— 1
Brewers' dried grains	6	19-27	23	30	0
Medium protein, 15-20%					
Wheat bran	52	11-18	15	27	— 2
Wheat middlings	44	11-17	16	31	— 2
Wheat mixed feed	48	13-18	16	31	— 1
Low grade (red dog) flour	14	15-17	16	35	— 3
Low protein, 8-15%					
Hominy feed	12	9-10	10	32	+ 1
Alfalfa meal	11	12-14	13	31	— 4
Dried beet pulp	4	8	8	29	— 1

Cottonseed meal sells at higher prices than ever before and is of poorer grade than ever before. Linseed meal also has gone up in price. The other concentrates, as compared with the prices at which they were sold at corresponding dates the previous year, were a dollar or two cheaper. The proprietary feeds on the whole sold at the same or somewhat lower prices.

Notwithstanding these changes in price, which in general are downward, it is still true that it is often possible to buy standard concentrates and make home mixtures of a high protein content at a saving as compared with the purchase of ready mixed goods of the higher protein grade. This statement is based on calculations which involve the use of reasonable proportions of the ingredients claimed, sufficient in each case to meet the guaranty statement made by the manufacturers. However, as the feed prices now are quoted, taking into account the cost of mixing at home, the prices asked for these high protein rations are not exorbitant; neither, on the other hand, is there any monetary saving as a rule in their purchase as compared with buying their ingredients.

The high protein ready-rations seem to be thoroughly desirable combinations; with rare exceptions high class ingredients are used in their construction. The molasses and stock feeds are of a different sort. Among the list of ingredients declared by the manufacturers of the high protein foods one finds but rarely the acknowledgment of the use of a manufacturing by-product of relatively inferior feeding value. It is quite otherwise with the lower grades. Among the molasses and stock feed statements one finds such ingredients as "ground grain screenings," "clipped oat by-product," "ground and bolted grain

screenings," "recleaned grain screenings," "oat clippings," "flax plant by-product," "cooked sphagnum," "grain screenings," "oat meal by-products (oat middlings, oat hulls, oat shorts)," "ground recleaned grain screenings," "oat hulls," "cob meal," "screenings," "ground corn and cob." Yet the prices asked for goods which proclaim the carriage of such material is but little less per ton than those asked for higher graded goods. Perhaps two to three dollars are saved. The fact that materials like "oat clippings," "cob meal," "ground grain screenings," etc., are not offered as such on Vermont markets and that their commercial values are not known to the writer, prevents the calculations upon which was based the above statements as to the relative money values of ready mixed and home mixed high protein rations.

STATEMENT CORRECTING ERROR IN BULLETIN 189

The Dewey Bros. Co. take exception to the statement made in bulletin 189 to the effect that their Corn 3D Dewey Grains was more than one percent below its protein guaranty, claiming that the guaranty as there set forth—namely 28 percent—was incorrectly stated, that it actually was 26 percent. They claim not to have received the station's advance notice of alleged shortage. They further say that they do not use tags, that the bags were indistinctly stencilled, and intimate that the sampling agent mistook poorly printed sixes for eights. They affirm most positively that never have they made a 28 percent guaranty on their goods.

The sample in question was taken by a careful sampling agent of long experience; yet it is conceivable that this suggested error occurred. It is obviously impossible to determine the facts by resampling, since a full year elapsed between sampling and protest. Hence the Station accepts the sellers' statement at face value and withdraws the remark to which exception is taken and the guaranty statement as printed upon which the remark was based.

IV. CONCERNING THE OAT CROP

By J. L. HILLS

INTRODUCTION

For eight years the annual feeding stuff inspection bulletin has been made the vehicle for the purveyal of an informational article dealing with feeding practice, following in this respect in the wake of the fertilizer control bulletins in which informational articles concerning fertilizers were issued for the first time in 1902. This practice is warranted by the somewhat wide latitude which is accorded the Station by the feeding stuffs law which permits it to include in its feeding stuffs inspection bulletins "such additional information in relation to the character, composition, value and use of such feeding stuffs as circumstances may advise." The feeding stuffs bulletins which have been of this character in the past have discussed the following matters:

1908. No. 138. The viability of weed seeds in feeding stuffs.

1909. No. 144. Concerning the manufacture and nature of feed; the economics of feed purchase; the formulation of grain rations; statement concerning feeding.

1910. No. 152. Principles and practice of stock feeding, including discussion of animal nutrition, feeding standards and sundry economic considerations, as well as a full glossary and tables displaying the several feeding standards, the average composition of roughages and concentrates, digestion coefficients and digestible ingredients and a "convenience table" giving the pounds of dry matter and digestible ingredients.

1911. No. 158. Concerning feeding standards, being a review of the energy value scheme; the Minnesota station findings and the Scandinavian feed unit system; summer soiling suggestions.

1912. No. 164. Condimental feeds.

1913. No. 171. Concerning the Vermont hay crop.

1914. No. 180. Concerning feeding practice; including discussions of what the cow does with the feed she eats, how to balance a ration, advisable roughages to grow, advisable grain feeds to buy, suggestions as to profitable milk production, and balanced rations for hens.

1915. No. 189. Concerning the corn crop.

It seemed advisable, since the hay crop had been discussed in 1913 and the corn crop last year, to review this year the other main Vermont roughage, the oat crop; and the present article is the result. There is nothing whatever original about it. It represents simply a compilation. Many federal and state publications as well as several of the more recent books dealing with this crop were used in its construction, especially farmers' bulletins 420 and 424 by C. W. Warburton, and Carleton's admirable book entitled "The Small Grains." The writer does not assume that the article is a complete monograph or anything more than a somewhat fragmentary presentation of the subject, loose jointed and none too well built.

ORIGIN

Only a guess can be made concerning the original habitat of the oat. It is thought to be western Asian or eastern European. It seems to have been cultivated first in northern and central Europe, within the confines of the present Russian Empire, being used there in animal feeding. It appears to have been sown in America by the earliest colonists. Its use in the feeding of the human kind is of comparatively recent date.

NATURE AND CLASSIFICATION

The oat is a grass, as much so as is timothy. Its stems are hollow and many jointed, averaging about 3½ feet in height; its leaves are rather broader and more numerous than those of wheat; its heads are of the panicle sort, either open and spreading or one-sided and closed, or, to use less technical terms, they are either of the spreading or of the "horse mane" or "banner" types. The oat grain is borne on small branches in "spikelets," 25 to 100 in number, enclosed within the "chaff," each spikelet as a rule containing two grains consisting of hull and kernel, the latter comprising two-thirds to three-fourths of the weight of the grain.

The modern classification of oats as given by Carleton recognizes seven distinct sorts; namely

1. The common or spreading oats, within which is comprised the vast majority of all cultivated varieties; characterized by spreading panicles or "tops."

2. The Oriental or side oats, also known as "banner," "horse mane," or "mane" oats; commercially important; of relatively recent

origin; characterized by compacted panicles or "tops," turned to one side like a horse's mane.

3. The hulless or naked oats; grown in central and eastern Asiatic highlands; commercially unimportant; "freaks" as it were.

4. The red, Mediterranean or "rustproof" oats; grown somewhat in the southern sections of this country.

5. The hairy or sand oats; commercially unimportant; a weed.

6. Short oats; commercially unimportant; slightly grown in western Europe.

7. Abyssinian oats: a wild African form; of no commercial importance.

Oats are classified commercially as white, mixed (all colors), red, rustproof, white clipped (the sharp ends of the grain clipped off and the grain otherwise improved in appearance, thus making them grade higher and weigh more), mixed clipped, and purified (chemically treated).

EXTENT OF THE CROP

Ninety-nine percent of the commercial crop is produced in the northern portion of the north temperate zone, doing best in such cool, moist climates as obtain in northern Europe, Canada, the American Northwest, in northern New England and in the states bordering on the Great Lakes. It is grown to some extent in central Asia, South Africa and the Argentine. The world's crop under normal conditions approximates four billion bushels annually, about one-fourth of which is grown in the United States. Oats rank fifth in value and fourth in acreage among American crops, being outclassed by corn, cotton, hay and wheat. Half this crop is grown in the five states of Illinois, Iowa, Wisconsin, Minnesota and Nebraska and a quarter in another five, namely, Indiana, Ohio, New York, Michigan and Pennsylvania. Indeed, every fifth acre of Wisconsin's improved farm lands is sown to oats, every seventh such acre in Iowa, Illinois and Minnesota, every tenth in Nebraska, Indiana and Michigan and every twelfth in Ohio, New York and North Dakota.

VERMONT'S OAT CROP

The census taken in 1909—a relatively unfavorable season for oats—showed that 71,510 acres were sown to oats in Vermont, and that 2,141,357 bushels were grown, an average of 30 bushels to the acre.

This was two-thirds as much again in area and one-fourth as much again in yield as were sown or yielded in corn. Indeed, the area in oats was greater by one-tenth than the combined areas planted to corn, wheat, barley, buckwheat, rye, peas and dry beans. Nearly two-thirds of the entire acreage and yield were grown in the five Champlain valley counties. The average area planted during the years 1900 to 1909 inclusive was 81,456, the average production 2,929,547 bushels, the average acre yield 36 bushels, which was exceeded only by the yields in the Northwestern and mid-Rocky Mountain States (35.9-46.3 bushels) and in Maine (37.1 bushels). The crop represented 1.4 percent of Vermont's total area. In other words, during these ten years one acre in every 71 acres of Vermont's entire area, including forests and mountains, was planted to oats.

The 1916 edition of the book on "Vermont Farms" issued by the Vermont Bureau of Publicity, Essex Junction, Vermont, says, touching her status as an oat growing state, that

"During the forty-year period, 1870-1909 inclusive, Vermont's average yield of bushels of oats per acre was the largest of any state in the Union. Last year (1914) only four states surpassed Vermont in the yield of bushels of oats per acre, and all these states were in the irrigated region of the West. Vermont's average yield was 42.5 bushels, while that of the United States was 29.7 bushels.

"Vermont's average yield for the past two years was 40.7 bushels per acre while the average yield for the United States for the same period was 29.4 bushels per acre. Vermont's average yield for the period, 1870-1909, was 35.1 bushels per acre, while the average for the United States for the same period was 27.6 bushels per acre.

"The states producing the largest number of bushels of oats in recent years are Iowa, Illinois, Minnesota, North Dakota and Wisconsin. The average yield of oats per acre in these states during the past two years was as follows: Iowa, 33.7 bushels; Illinois, 26.5 bushels; Minnesota, 32.9 bushels; North Dakota, 26.8 bushels; Wisconsin, 31.7 bushels. Not one of these states equals Vermont's average.

"The average Vermont price to farmers December 1 for the two-year period 1913-1914, was 53.5 cents. The average price for the period throughout the United States was 41.5 cents. The average price per bushel during the last four years in the states producing the largest number of bushels of oats was as follows: Iowa, 37.5 cents; Illinois, 41 cents; Minnesota, 36 cents; Wisconsin, 40 cents. Vermont's price was far better than that paid by any of these states. For the forty-year period, 1870-1909, the average Vermont price was 43.5 cents per bushel, while the average price for the whole country was 32.3 cents per bushel.

"In 1914 Charles G. Cady of Middlebury raised 1901¼ bushels of oats on 32½ acres, or an average of 58½ bushels per acre. The average yield per acre for the United States in 1914 was 29.6 bushels per acre." (Which it may be remarked parenthetically is less than

two-thirds of Germany's acre yields. However, a comparison of this kind is always superfluous nowadays, since the whole world knows the "efficiency" of the German farmers).

Most of the crop grown in this country is home used, being fed on the farms on which it is grown. Less than one-third of it is shipped away. Prior to its export from its home locality its grade is sometimes bettered by the removal of inert matter, weed seeds and light oats by the process known as "fanning," or the market price and weight are increased by "clipping," a process which removes a portion of the hull from the grain tip. Sometimes discolored grain is bleached with sulphur or other chemical agents, a process which improves appearance, does not lessen food values, but is likely to impair germination. However, inasmuch as the feeding value of weathered or heated oats usually is the worse on this account, a lot thus furbished by chemical processes is likely to be less serviceable than its appearance would indicate.

THE SEED

VARIETIES

Varieties differ in color, size, shape, period of growth and ability to yield. They may be white or black, grey, yellow or red; they may be large and spindling or short and plump; they may need three months or they may need four and one-half months in which to mature. Some are spring, and some fall oats; and some are indifferent in this respect. The habit of growth also varies since some are spreading and some compact, the so-called banner or horse mane oats. So-called "lodge resistant" varieties have been vaunted, the value of which is more or less problematical.

Hundreds of varietal names exist and, as is common with most crops, it often happens that the same variety is named diversely in different localities or by different seed houses. New sorts spring up annually while older varieties pass into the discard and are forgotten. However, the number of varieties really adapted to the conditions of a given section is relatively small. A medium to late type usually is grown in the North Atlantic States, one carrying a large, plump white kernel. American Banner, Canada Cluster, Clydesdale, Probesteir, Swedish Select, Welcome and White Tatar are said by Warburton to be most commonly offered in this section.

Carleton establishes nine oat-growing districts in this country. In his "northeastern oat district" he includes the North Atlantic States (exclusive of southern New Jersey), West Virginia, northern Ohio, Michigan, the maritime provinces of Canada, Quebec and eastern Ontario. He states that white, spreading varieties usually are grown, citing the following as now grown or adapted to growth in this section: Abundance, Banner, Big Four, Cluster, Clydesdale, Daubeney, Lincoln, Long White Tatar, Ligovo, O. A. C. No. 72, Old Island Black, Silvermine, Swedish Select, Siberian, Tatar King, Victory, Welcome. He states further that mid-season or late oats seem to do better than early vareties; that in the more northerly regions earliness is an important factor in escaping rust, dry weather and in promptness of maturity; that the climate generally is well adapted to the crop; and that stronger straw, early varieties for northern sections and rust prevention are vital needs. This is an interesting epitome and is worth careful attention, because of the special knowledge possessed by its creator.

Any variety which is suited to the local conditions should yield well if given a favorable opportunity and if the seed is graded carefully, is plump, free from weed seed and trash, and is treated to kill oat smut. No hard and fast rule can be laid down with safety as to varietal choice. Soil, climate, altitude, latitude, affect the outcome. However, speaking broadly, the larger grained, medium to late varieties usually succeed best in the North. The close panicled or horse mane oats are likely to be hardier as a rule than the open panicled varieties and in regions where the season is long are likely to yield better; but in the long run in these latitudes the spreading varieties are more certain.

Oats vary greatly in weight, for the well known reason that the proportion of kernel to hull is highly unlike because of varietal, seasonal and other causes. Thus we have light oats and heavy oats. On this account legal weights of a bushel of oats have been established in most states, varying from the light weights in the southern states, typified by Maryland, 26 pounds, to the heavy weights of the far Northwest, typified by Idaho's 36 pounds. A legal bushel of oats in Vermont weighs 32 pounds. Of course "clipped oats" are relatively heavy. It is well understood that in buying and selling oats the weight always is specified.

The proportion of kernel to hull being variable, no fixed relation exists between bushel weight and kernel proportion. Usually oats run about two-thirds kernel, though they may be as low as 55 and as high

as 80 percent kernel with the average about midway between these extremes. The proportion of grain to straw is influenced also by varietal and seasonal conditions. It may be as low as 1 to 1.3 or as high as 1 to 4.

As between varieties bearing relatively short plump grains and those with longer and more slender kernels there seems little to choose. The Illinois station after five years' trials found that the latter yielded a larger proportion of kernel to hull, whereas the Ohio station as a result of a trial with large numbers of varieties, arrived at the opposite conclusion. It appears that the varieties producing the more slender grain as a rule take more time to mature and in a short season might not fill well, thus increasing the proportion of hull and lowering the weight of a measured bushel. On the other hand the varieties with short, plump grains, maturing as they generally do somewhat earlier and hence becoming well filled out, are likely to yield more kernel proportional to the hull. All this means, in brief, that the ratio of kernel to hull is affected by the character and length of the growing season. Most American varieties are of the shorter, plump kernel type, ripening relatively early and thus escaping the ill effects of the summer winds.

SELECTION

If one seeks through seed selection to better his crop he should understand in the first place that the seed must be cleaned thoroughly and the larger grains chosen. It is suggested often that new seed be bought at a distance, advice which may or may not be worth taking. Unknown or ill adapted varieties should be declined. If one seeks new seed, whether of the same or of a different variety, and if one is to go outside of the immediate vicinity, seed should be sought grown in a drier and a colder climate rather than that grown in one less dry and warmer, for the crop grown in dry and cool regions is more likely to withstand untoward conditions than that grown in a moist and warm country. Many of our best sorts are of European origin, doing well when grown under climatic conditions resembling those of their native land. Thus Swedish oats grow well in this latitude and varieties from South Russia in the midwestern states. Indeed, most Russian varieties used in this country are of relatively high grade and are among our most valuable grain assets.

Heavy or light oats. Seed oats should be looked to with care. The better grades are screened and fanned in order to separate the

light oats, small oats, weed seeds and "trash." The former germinate poorly and yield a relatively light crop; the latter are an obvious detriment. In one series of trials carried on for many years, heavy, common and light seed yielded in the ratio of 100 : 97 : 89, and in another in the ratio of 100 : 97 : 92, and in yet another in the ratio of 100 : 87 : 75. The heavier seed produced heavier oats and the lighter seed lighter oats.

Field selection. While it is well always to select large and heavy seed at the fanning mill or when making direct purchase, field selection also is worth considering. The yields and the quality may be augmented by choosing the best heads or plants in the field, by thrashing them in a lot by themselves and by planting them apart from the main crop, thus developing a special strain. A yet further refinement of this method, one not often resorted to except in the conduct of breeding trials, is thus to handle individual plants. Zavitz at the Ontario Agricultural College during many seasons consistently selected and sowed heavy, plump grains in comparison with those of lighter weight and reaped a harvest one-third greater as a reward for his work. He states that a 15 percent increase over average yields easily is possible if care is exercised in seed selection, a statement amply confirmed by the results of similar work carried on in other localities.

A concrete example. An excellent illustration of this matter of seed selection is afforded in the concise account given by the cerealist of the Federal Department of Agriculture in his recent book on "The Small Grains," setting forth the facts as to the "Swedish Select oats." This variety "was introduced into the United States by the author in the spring of 1899. It was obtained, along with other cereals, while making an exploration of the cold and semi-arid regions of Russia and western Siberia in 1898-99 in search of cereals adapted to corresponding conditions in this country. This oat apparently originated at Svalof, Sweden, as a pedigree variety developed by selection many years ago, and was grown afterward in Finland and in Petrograd province, Russia. Under the severe weather conditions of these localities it became acclimatized for a cold and dry climate.

The Swedish Select is a large-kerneled white oat, with a spreading top or panicle. The distinguishing marks are a blunt, plump kernel, usually with dark, slightly twisted awns and a heavy weight bushel. It is a very prolific variety, which quality, together with the size and weight of the kernel, no doubt is the result of previous selection. The usual weight of a bushel is 34 to 36 pounds, while in Montana a weight

of 44 to 46 pounds is not rare. Comparisons of yields with other varieties therefore should be made on the basis of bushels by weight instead of measured bushels. Swedish Select also grows to a considerable height and produces much straw, its chief fault being a tendency toward overproduction of straw when grown on rich or low land. The roots are large and vigorous, giving the plants hardiness in cold or dry seasons. In the northern United States between the Great Lakes and the Rocky Mountains, the average annual production of this variety is at least 50,000,000 bushels, and in 1910 it was estimated that the annual farm value of the oat crop in Wisconsin alone was increased over $2,000,000 by virtue of the presence of this variety."

Oat breeding. The methods used by plant breeders in their efforts to improve by selection are several. While few farmers would carry out these requirements of care, a brief account of their processes seems worth including at this point. There is, in the first place, the sorting of the strains from admixtures caused by threshing operations, or by the use of several varieties on the farm or otherwise, a process involving hand picking the seed or the separate plants. Then the foreign plants, e. g., wild oats, barley, etc., must be removed from the standing crop, "roguing" as it is called. Then the cleaning and grading of the grain must be done, either by means of an air blast, by means of gravity or through specific gravity separation. The old time winnowing process roughly grades the seed, but the more modern fanning mill with its sieves of different mesh accomplishes a more effectual grading. A vertical series of sieves ranging from coarse to fine, set each at an angle with its neighbor, through which the grain passes of its own weight, serves to make separates on the basis of the size and shape of the kernels. And, finally, if the grain is immersed in a liquid—usually salt water—of such a density that kernels of average weight barely will sink, all the lighter kernels, the chaff, trash and many weed seeds float and may be skimmed off. It has been suggested by Derr that the solution used in smut treatment may be used to good advantage, thus killing two birds with one stone.

The improvement of the species has been secured yet further through the process of so-called "mass selection," the choice of the best plant from a plat or field for mass sowing in a separate field; by individual or "pure line" selection, that is to say the choice of a single, superior mother plant, which, with its resultant seed, is kept safe from cross pollenation, a process which contemplates vast numbers of such

selections, protections and propagations, and, finally, the rigid elimination of the unfit and the isolation, propagation, increase and distribution of those fittest to survive.

Of course some work has been done along hybridizing lines, although less attention has been paid to this means of varietal improvement than to introduction and selection. Thus the Swedish Select, Clydesdale, Kherson, and Sixty-Day oats were introduced from foreign countries and improved by rigorous selection; but we have as yet no oat hybrids which are now commercially important.

TREATMENT FOR SMUT

Since the best of oat seed may be smutted, and since both the price and the quality are impaired seriously if the grain is smutty, a formalin or copper sulphate treatment, or a hot water dosage should be given the seed. One never is safe. Smut may occur any year. The threshing machine may bring it to a farm which never before has been infested. The seed may be soaked in the solution or it may be sprinkled upon the grain. The solutions, either of which may be used, are made up as follows:

(a) 1 pound commercial formalin (formaldehyde) to 40 gallons water.

(b) 5 pounds copper sulphate to 50 gallons water (suspended in a bag over night in the 50 gallons of water in order to facilitate solution).

Soaking process. Two vats (half barrels) are so placed that one will drain into the other. The upper vat is filled half full of the fungicide, the grain poured in, and thoroughly stirred. It is removed in ten minutes, piled, allowed to drain, spread out and shoveled frequently to facilitate drying. If copper sulphate is used, a ten minute immersion should be considered to be the extreme time limit, lest injury ensue.

Sprinkling process. This is less laborious and quite as effective. Smaller amounts of the fungicide are used but the proportions of disinfectant and water are the same. If copper sulphate is employed, the grain is piled in a heap on a clean floor and wet with an ordinary sprinkling can, not drenched but evenly moistened; it is shoveled as quickly as possible into another heap and back again until every grain is well wet; and then it is spread out to dry. If formalin is employed, the moistened pile is left for two or three hours, covered with sacks and then spread out to dry. A gallon to a bushel will suffice.

The hot water dosage is cheap and effective but must be done with much care. The temperatures must be just right, neither higher nor lower than is prescribed; and the thermometer must be accurate. Since thermometers are notoriously unreliable and since a change in altitude affects the boiling point, and since Vermont is a state of varying altitudes and, finally, since formalin is effective and cheap and relatively safe to use, it hardly seems worth while to describe the hot water treatment.

THE SOIL

TYPE

The relatively heavy soil types usually are apt to grow better oat crops than do the lighter sorts, although the latter, if well started with available plant food and if underlain with a fairly retentive subsoil, sometimes prove satisfactory. A slightly rolling piece is advisable, since its drainage is likely to be the better on that account. Heavy, wet clay and low undrained soils in general are not adapted to the growing of oats, neither are the richer types, since the crop is likely to be overfed, to grow too rapidly, to be weak-stalked and to lodge, as well as to be especially subject to plant disease. Yet on the other hand it should be remembered that few if any cereal crops use more water than oats in making a pound of dry matter, and that on this account a naturally retentive soil, one well stocked with humus, is needed.

SEEDING

Relatively little attention usually is paid in this section to the preparation of soil for the oat crop. Any procedure which will furnish a loose surface soil underlain with a fairly firm subsoil is thought to serve the purpose. There are those, however, who believe that greater care in seedbed preparation is well worth while. When following corn the seed quite commonly is broadcasted without any preliminary soil preparation whatsoever, a practise which, as a rule, is not to be advised. The land rarely is plowed, but usually both disking and harrowing are necessary to prepare the moderately fine seed bed with loose soil surface which is adapted best to the purposes of this crop. Experimental trials seem to indicate that at least as large a crop follows thorough disking as follows plowing. Since the crop is sown early and since a spring-plowed soil rarely can be put into shape soon

enough, a piece which ought to be plowed should be handled thus in the fall, and be disked and harrowed in the following spring.

Date. Oats should be sown early, as soon as the land can be worked, since excessive heat injures the crop. They are sown in late April or early May in the northern states. This cool climate, cool weather crop laughs at spring frosts. Sometimes oats are sown in the late fall in order that they may be ready to germinate in the early spring, a procedure which lessens spring work and secures early germination, if the dangers incident to winterkilling and to alternate freezing and thawing during the winter are avoided. This practise is hardly to be advised in New England.

Rate. The amount of seed used varies with the soil and seeding methods. Seed goes farther on good soils than on poor soils; on clean soils than on weedy ones. If the crop is drilled, less seed is needed than if it is broadcasted. If selected seed is used, less is needed than if ungraded seed is sown, for the larger seed grows larger plants. From 8 to 12 pecks commonly are sown. The rate of seeding, within limits, does not seem materially to affect the yield, since the plants on thinly seeded pieces tiller enough more than the thickly seeded plants to make up for the difference.

Method. Oats usually are sown broadcast and harrowed in. If evenly distributed—which is no small task—and covered about an inch deep, the job is well done. Less seed is used as a rule when it is drilled. A better germination and a larger crop are secured. The results of many experimental trials are indeterminate as between broadcasting and drilling.

Depth. Shallow seeding usually is to be preferred, one to two inches deep, the former on the heavier types, the latter on the lighter. On a well disked field seed can be put in well by a couple of harrowings, though it should be remembered that a broadcasted seed never can be covered with perfect evenness.

FERTILIZATION

The soil may be lacking in one or more of several particulars. For example, it may be deficient either in nitrogen, phosphoric acid, potash or lime, in any two or more of them; they may be abundant but unavailable; the soil may be acid, in a toxic condition or physically poorly adapted to crop growth. To a greater or less extent these soil ills may be remedied by adequate fertilization, by crop rotation and by cultivation.

Careful and repeated experimental trials have proved that almost as much plant food is used in the production of a crop of oats as in growing any other cereal. This statement runs counter to the commonly accepted notion that the poorest land on the farm is plenty good enough for the oat crop. It is true that the oat crop is an avid feeder, that it can forage to better advantage than many other plants, that it will endure hardship better than will most cereals; but that does not mean that it will not respond to kindly treatment or that a judicious application of a well chosen commercial fertilizer may not be likely to prove profitable. Indeed, it is a shallow feeder, rooting in the upper two feet. Yet the fact above alluded to, that on over-rich soils the stalks becoming soft and weak cause the crop to lodge and to become the prey of plant disease, makes it difficult in the application of fertilizer for the farmer to steer between the Scylla of a scanty yield and the Charybdis of a lodged crop. Fertilizers are best applied with a grain drill attachment and at the time of sowing.

The use of barnyard manure rarely is wise, unless the soil is very poor and especially lacking in humus. It is better applied to a previous crop, such as corn. If the oats follow the corn in the rotation they will benefit by manurial residues, a rank growth of straw and lodging will be less likely and a larger grain yield more likely to occur than when manure is applied directly. Green manuring is seldom resorted to in this land of the cow and need not be described here. It is rarely worth while at this particular point in the rotation.

It often happens that small applications of nitrogenous fertilizer may be made to good advantage, more particularly with a view of forcing early growth and carrying the crop through the so-called "pouting" season. Oats grow rapidly and early in the season, before the weather warms up much and before nitrification becomes active. Consequently a modicum of nitrate of soda often works well. This is particularly true if the crop is to be hayed, a custom which is becoming increasingly common; for, as is well known, nitrogen tends to promote foliaceous growth and to retard maturity. Barnyard manure may be used to good advantage if the crop is to be hayed.

Available phosphoric acid is more likely to be the controlling plant food factor in the growth of a good oat crop than are either nitrogen or potash, although of course there are many exceptions to this rule. As the French say "no general assertion is wholly true—not even this one." It is held generally that a liberal use of available phosphoric acid tends to strengthen the stalk, to improve the quality of the grain

and to lessen the likelihood of lodging; although any crop, no matter how well or how strong of stalk, may go down before summer storms.

Potash, even in the years when it is abundant—which certainly is not 1916—may be used to better advantage elsewhere, especially if the soil is relatively heavy. The crop rarely will note its omission on the clay loams. On the lighter types, however, its use has proved at times to be profitable.

Liming is of little use, although if the soil is very acid it may be worth while. It usually has little effect, one way or another. However, if a clover or grass crop is to follow the oats, often it will be sufficiently benefited to warrant the application of lime.

On the heavier soil types it is advised to apply about 50 pounds of nitrate of soda and 150 pounds of acid phosphate, adding perhaps in normal years on the sandier soil types, 20 to 30 pounds of muriate of potash.

In this connection, the specific suggestions made for 1916 fertilization, in Circular 10, dated December, 1915, seem worth reprinting. These, it should be noted are designed full more for a hayed crop than for one which is to be thrashed.

"*Oats, barley, seeding down to grass.* It is, of course, a common procedure to sow grain following corn directly or with a year's interval, depending upon the residual plant food for the forcing of crop growth. If a fertilizer is used at all, nitrate of soda may be sown in small amounts, or a 300 to 500-pound application may be made in the spring of a ready mixed or home mixed goods carrying 4 to 5 percent nitrogen and 8 to 10 percent available phosphoric acid. The nitrogen should be used largely in the mineral form, and preferably as nitrate, for reasons hitherto cited, though cost considerations may make it impracticable to do this. If the seeding is done in the fall, or if winter rye is sown, no nitrate should be used. (In this connection see the discussion of seeding down fertilization for grass, oats, barley and clover on pages 186 to 189 of Vermont station bulletin 171; free for the asking)."

In this connection the following statement touching the guaranteed composition of 22 "oat" or "grain" fertilizers sold in Vermont is of interest, as indicating the extreme differences of opinion among fertilizer manufacturers as to proper formulation for this crop. The 1914 guaranties are used for the reason that the character of the 1915 and 1916 brands is of course abnormal on account of potash shortages.

	Nitrogen	Available phosphoric acid	Potash
Four consist simply of acid phosphate and muriate of potash	..	10	2
Five contain acid phosphate, muriate and a little organic matter	¾	7-8	4
One carries a little organic matter, acid phosphate and a very low potash content	¾	7	1
Two carry a little more nitrogen and potash than the last	1¼	7	2
One carries medium to low percentages throughout	1¾	8	3
Three carry medium to low nitrogen and phosphoric acid contents but a high potash percentage	1¾	8	10
Three contain high nitrogen and potash contents..	3¼	6-10	7-10
Two carry high nitrogen, low phosphoric acid and high-medium potash contents	5	4-5	6
One consists approximately of ½ nitrate of soda, ⅛ muriate of potash, with phosphatic organic matter, probably bone, making up the residue.	8½	4½	8

The brands first listed are the lowest grades sold in Vermont, and the one listed last is the highest grade sold; yet both are designed for and both labeled "oats"; and, paradoxical as the statement may sound, both may work well when advisedly used. The high grade goods applied as a topdressing used in moderation and for a crop that is to be hayed, may be just the thing to use; or it may do much damage if freely used on fairly rich ground. The low grade goods, sown on land where the previous crop was well manured, may serve a good purpose. However, all these various sorts of combinations cannot be equally well suited to the growth of the oat crop. The extremes can be defended; but some of the intermediates, particularly those carrying high potash contents, seem "neither fish, flesh nor good red herring."

When all is said and done, however, it should be remarked that the oat crop stands in less need of fertilization than do most crops. Prolonged field experimentation at the Ohio station indicated that as a rule when complete fertilizers were sown the increased crop barely paid the fertilizer bill, but that when acid phosphate was used on oats to be threshed a marked crop increase often ensued, more than enough to reimburse the outlay for this ordinarily low cost source of plant food. It is very doubtful, however, in view of the present high cost of acid phosphate—nearly twice what it has cost in previous years—whether or not this statement now holds good.

CULTIVATION

Rolling after seeding has taken place may be worth while on the looser soil types, since it serves to warm them, to hasten germination

and to increase yields; but it works ill on the heavier soil types. It is often well to follow the roller with a light harrow, since this forms a soil mulch and thus tends to retard evaporation. Actual cultivation is not often practised in this section, although after the oats are up the harrow with teeth at a 45 degree angle is sometimes run over drilled oats, parallel to and not crosswise of the planting, in order to lessen moisture losses. Such a practice is not advised if the seed has been broadcasted. During very dry seasons a light weeder is sometimes used.

WEEDS

Weeds, of course, are very undesirable soil inhabitants. They occupy much room which the crop could fill to much better advantage, crowd it and reduce the yield; they retard the growth of the infant crop; they consume plant food and soil moisture which otherwise would be available to crop growth; they sometimes tend to increase the extent of insect and fungus infection; their seed is a nuisance in threshing, their tops reduce the value of the hay and the value of the product is impaired; and it costs money to handle them at harvest. Any means whereby the oat crop can be made as nearly as may be weed free is worth thinking about.

Now most of the weeds in the oats are sown by the farmer. He buys and pays for them. The analyses of six samples of seed oats as printed in bulletin 192 show that one lot has 135 weed seeds to a pound. If a bushel of this seed is sown to the acre, a rather light seeding, more than 4,000 weed seeds are sown per acre, about one every square yard; and this was not a very bad lot of seed as seed goes nowadays; and each seed germinating and maturing may increase a thousand fold. Furthermore, some weed seed may lie dormant for years before germinating.

The weeds most common in Vermont oat fields are the wild mustard or charlock, popularly known as kale, and common ragweed. Hand eradication is of course out of the question. Clean seed and crop rotation will tend to control them. Wild mustard (kale), which is especially troublesome, may be controlled by spraying with iron sulphate, using 75 to 100 pounds to a barrel (50 gallons) of water. It is best applied before the older weeds come in blossom, otherwise seed may ripen even after the leaves are killed. A cloudy, "muggy" day with rain not immediately imminent, is the best time to choose. Cereals and grasses are not materially hurt by this spray; clover and alfalfa

may be injured; and kale is killed. A potato spraying machine should serve the purpose. Under normal conditions the cost for materials is about $1.25 an acre; under present abnormal ones, much more than this.

THE CROP

Oats are grown for various purposes; to be hayed, thrashed, as a cleanser of soils, as a nurse for other crops, as a soil cover, and as forage, either alone or in conjunction with other crops. It is grown in rotation or sometimes continuously. In fact oats are a versatile crop.

Rotation.—An oat crop commonly follows a hoed crop and precedes grass. If this order is reversed, weeds, rankness of growth and lodging are likely to cause trouble, although, speaking broadly, oats are not as apt to be unfavorably affected by ill advised rotational plans as are other cereals. A common New England rotation is corn, oats, and grass and clover sown with the oats; a rotation often used in Maine potato growing regions consists of potatoes, oats and clover in a three-year succession; and a common mid-western five-year rotation consists of corn, corn, oats, grass and clover seeded with the oats, grass and clover. (In this connection, see the discussion of the crop rotation in bulletin 190).

As a cleansing crop. Their habit of early growth and the dense shade they cast make oats an admirable cleansing crop. When weed control is an important issue, a heavy seeding is advised. The crop may be either hayed or thrashed, but in either event should be cut before the weeds mature. Following the harvest the land should be pastured or else the weeds should be mowed or plowed under, the plowing being supplemented by occasional harrowing in order to destroy further weed growth. If a piece thus treated is planted to corn, potatoes, or other hoed crop the next year, its weed population will be likely to be eliminated by the end of the second season.

As a nurse crop. Oats are often thus used as a nurse for grass and clover, but this practise has its drawbacks, for the reason that the oat foliage is dense and the draft it makes on soil moisture great. The nurse sometimes uses so much water that the nursling suffers for thirst; and when the leafy parasol is furled the young plants wither. Then again the proneness of oats to lodge militates against their use for this purpose, as they are apt to smother the nursling crop. Barley serves a better purpose. If oats are used, the small and earlier varieties are to be preferred, because their water usage is less and they are

harvested before the extreme hot weather comes on. Furthermore, a relatively light seeding drilling in and not broadcasted is advised in the interests of the new stocking. And, finally, the crop should be cut with a high stubble in order to protect and support the young crop.

As a cover crop. Oats are sometimes used as an orchard cover. Their heavy drafts on soil moisture serve to check tree growth and to harden the young wood; and their dense foliage serves to shelter the soil against overheating and to afford winter protection as well. Sometimes peas or vetch are sown with the oats, a practise which is generally advisable because of the increased nitrogen accumulation thus induced.

With other crops. Oats are often sown with other crops, more particularly Canada peas, rape or barley. Peas and oats are frequently grown for pasturage, soiling or for hay and they are sometimes thrashed. A bushel of peas to one to one and a half bushels oats are sown, at the rate of two to three bushels per acre. Sometimes vetch is used in lieu of peas, two parts vetch to one of oats. The yields and quality of the forage are improved by these admixtures.

When rape is used as an adjunct crop, the seed is usually sown lightly and harrowed in, a pound or two to the acre, a few weeks after the oats have been put in. This delayed sowing ordinarily gives the oats such a start that they can be harvested without difficulty, following which, if a rather high stubble is left, the rape crop grows rapidly and makes excellent sheep or hog pasturage. Of course it may be so sown as to be cut with the oats or oats and peas as a soiling crop.

Excellent grain yields often follow a mixed barley-oats seeding, particularly if early varieties of oats are used which ripen with the barley. This practise is common in Ontario where the crop is usually home-fed. Early Daubeney oats and Manchuria barley or Siberian or Banner oats and Chevalier barley have worked well.

CROP PESTS

Smuts. There are two oat smuts, both of which are destructive. The common or loose smut occurs to a greater or less extent wherever oats are grown. It destroys the entire grain, replacing it with a mass of black powder made up of the spores of the parasite. Entire heads sometimes are thus affected. The infected plants are somewhat stunted and the panicles shortened and constricted. A somewhat less common form, the so-called closed or covered smut, injures the kernels only and the spores are enclosed within the chaff. Indeed the smut spores

gain their access into the growing parts of the plant at the time when the seed is germinating and they finally develop in the head. When an untreated smutty seed is sown, a smutty crop is likely to ensue; for the conditions which favor seed germination promote fungus development. Both smuts are easily combatted by the use of formalin, as is set forth on pages 55 and 56. This disease is sometimes prevalent in eastern oat fields and is often found in the West. One year with another it is thought to cause a loss approximating 3 percent of the total crop, a loss which mounts far up among the millions.

Rusts. Rusts are characterized by the appearance of roughened, irregular areas on the foliage and by spore discharge. There are two or three forms. The black rust is the more destructive, but the crown rust the more common. These maladies, attacking as they do the stem and leaves, naturally weaken the plant, interfere with its assimilative powers and lessen its ability to construct a crop of full kernels. The damage they do the country over is probably greater than that wrought by the smuts, but unfortunately they cannot be successfully combatted, save by early seeding, the planting of early varieties, the avoidance of ill-drained, over-rich soils and of highly nitrogenous fertilizers. Fortunately for us they are not as great a factor in oat raising in this section as they are further west and south.

Insects. Oats are not seriously troubled by insects. Chinchbugs, green aphis and army worms occasionally molest it in other sections and rarely in New England, in which event the burning along fences and in fields of the rubbish in which they are likely to hibernate may prove helpful. However, it does not often pay to spend much time and effort in fighting these pests, so far as the oat crop is concerned.

Stored grain is often injured by grain weevils and moths. Indeed the damage done in the country as a whole is placed at $50,000,000 annually. Their greatest havoc is wrought in the South and in the large grain storage centers, in cereal and feed mills, warehouses, seed houses, grocery stores, etc. The ravages may be controlled by heating to a temperature of approximately 120° F.; or by fumigation with carbon bisulphid or hydrocyanic acid gas. The heating process is of recent development and seems to be an admirable method when possible to apply. The use of the gas is less desirable. Both hydrocyanic acid and carbon bisulphid are highly poisonous, and the latter is inflammable as well. Tight bins and well informed and careful operators are needed if one is to attempt to "gas" these pests.

HARVEST

Early varieties mature in from 90 to 100 days; late ones in from 115 to 130 days. Oats are cut just before or as the heads begin to turn yellow, in the hard dough stage, either with a grain binder, cradle or a mower (when lodged), raked and cocked. If cut earlier than this, the kernel is immature and light in weight; if allowed fully to mature before harvest, the crop shatters, the grain discolors and in other ways is subject to loss. However, on large areas harvest should begin a bit early lest too much be cut too late. The grain is commonly shocked in the field where it ripens prior to thrashing. If green or weedy or if it has been wet by rain or dew, it is well to allow it to dry out a bit before shocking. Both round and oblong shocks are used, the latter being preferable if the crop needs to dry out further.

Shocks should be well built so that they will not blow over or expose the grain to adverse weather conditions, thus injuring color and quality. They may be covered with cap sheaves, a bundle or two firmly placed on top protecting the heads.

Just how the grain will be handled and kept between the time of cutting and of stacking or threshing, will be determined by the good judgment of the farmer. It is rapidly becoming the custom in many sections to thresh directly from the field. This procedure saves time and labor and expense, and works well whenever weather conditions favor and the crop will thresh well. If storms intervene, of course the outcome is less satisfactory. A grain which is not fully dried out is likely to heat, unless frequently stirred. It is of course often difficult to get the thrashing crew at the psychological moment.

Stacking is not as common in this section as in the grain growing states, where delays in thrashing necessitate the protection of shocked grain against the weather. It is quite an art to make a good stack, full-middled, properly bulged and well-topped. It is sometimes mowed away after it has dried out in the shocks there to remain until it is thrashed.

Oats must be thoroughly dry when thrashed. A better job is done and a better product obtained, one which is less likely to heat and mold than if an ill dried crop is handled. It were well to make sure that the machine is clean before it begins work and that it is doing its work properly, making as nearly a complete separation as possible. The straw is stacked or run into the barn as is most convenient.

The grain should be stored in clean bins above the ground level in such a manner that mustiness and discoloration may not occur. Being dry, it should be kept so. Oats readily absorb water and become musty. Musty oats have less feeding value than bright oats and, indeed, may be dangerous. They should be so stored that they may be kept vermin-free and insect-free. The large storage warehouses, elevators, etc., are usually so constructed that their bins may be fumigated.

COST OF A CROP

What does it cost to grow a bushel of oats? Many items, of soil preparation, seed, yield, thrashing costs, sundry overhead charges, enter into the determination of the matter. Estimates based on careful experimental studies are: Illinois 36 cents, Minnesota 23 to 31 cents, Iowa 29 cents, Wisconsin 31 cents, Nebraska 30 cents, Ontario 22 cents. Farmers' estimates often are lower than these figures, but they are likely to be fallacious, for farmers rarely give due consideration to such items as interest and the like. The statement has been made following an exhaustive series of comparisons that from five to eleven cents profit was made on a bushel of oats, exclusive of the by-products; and that crops of 25 bushels or less per acre were usually grown at a loss. It is quite safe to say that the margin of profit in growing oats is narrow and that high acre yields only are likely to prove profitable. Farmers, especially in the grain growing districts, are prone to hold grain in the home storage as against better prices. Such as contemplate this procedure should see to it that their bins are built so as to be light, well above ground and that they are so protected with metal lining or otherwise as to be rat and mouse proof.

FEEDING

CHEMICAL COMPOSITION AND DIGESTIBLE NUTRIENTS

The following data drawn from bulletin 152 show the composition, digestible nutrient content and fertilizing value of the oat plant and of its more common separates.

	Composition						Digestible nutrients					Fertilizing constituents		
	Dry matter	Ash	Protein	Crude fiber	Nitrogen free extract	Ether extract	Dry matter	Protein	Crude fiber	Nitrogen free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Fodder	62.2	2.5	3.4	11.2	19.3	1.4	23.4	2.5	6.2	12.0	1.0	0.49	0.13	0.38
Oats and peas.	78.7	1.7	3.5	6.0	9.1	1.0	14.9	2.6	3.6	6.1	0.6	0.56	0.12	0.54
Hay	15.0	5.2	9.3	29.2	39.0	2.3	45.9	4.8	14.0	21.8	1.5	...	...	...
Hay	8.9	6.2	7.6	29.3	45.1	2.9	49.2	4.0	14.9	24.8	1.8	12.2	0.50	0.80
Oat and pea hay	11.5	6.6	14.8	24.9	38.9	3.3	54.0	10.8	14.4	23.7	1.9	2.37	0.54	2.25
Straw	9.2	5.1	4.0	37.0	42.4	2.3	43.6	1.2	20.0	18.7	0.8	0.62	0.20	1.24
Oats	11.0	3.0	11.8	9.5	59.7	5.0	62.3	9.2	1.9	45.4	4.2	2.06	0.82	0.62
Hulls	11.5	6.6	14.8	24.9	38.9	3.3	54.0	10.8	14.4	23.7	1.9	2.37	0.54	2.25
Kernels	7.9	2.0	14.7	1.0	67.3	7.1	...	..	..	...	..	...	...	...

The green forage compares favorably with green corn fodder but is not quite as good as are green barley or rye. The addition of peas of course improves the forage, whether it is fed as a soiling crop or made into hay. Oat hay is better as a roughage for dairy feeding than timothy but hardly as good as barley hay. Since, however, barley hay, because of its beards, often is not as readily eaten as is oat hay, this difference is perhaps more apparent then real. Oat straw is distinctly the best of the cereal straws and compares fairly well in feeding value with corn stover. Notwithstanding the fact that oats are about one-third hull and about two-thirds kernel, they are quite as proteinous as wheat, more so than corn and nearly as much so as barley. Their fat content also is larger than that of any other grain and they contain considerable mineral matter. It is easy to see why oats occupy a prominent place in the feeding of the young. This is preeminently true of the kernel which is one-seventh part protein, two-thirds parts carbohydrates together with 7 percent of fat. One has but to compare the heartiness of his rolled oats breakfast as compared with that of any other cereal, be it corn, rice, wheat or what not, to appreciate the fact that oats are a rich ration.

The digestibility of the plant and its separates of course is an important matter. The hulls are relatively indigestible, but on the other hand they serve the useful purpose of giving bulk to the grain ration and lightening what otherwise might prove an over concentrated ration, thus tending to facilitate the process of digestion. This fact, however, does not warrant the excessive use of extraneous hulls, as in some proprietary mixtures offered on our markets. The entire grain

contains as much digestible protein as do barley or corn and practically as much as wheat and as much digestible fat as corn and more than that in barley and wheat. Its carbohydrate contents are somewhat less, for obviously no grain can exceed others in all respects. Oat straw outclasses all others in digestibility and in its digestible nutrient content; and oat hay is superior in this respect to timothy.

The oat plant and all its separates are fed to stock; and the oat kernel enters into human food to a large extent.

ROUGHAGES

As a soiling crop. Oats or oats and peas make a good soiling crop. We have grown 19 tons of green forage to the acre, containing more than five tons of dry matter, equivalent to six tons of hay. Analytically it compares favorably with the red and alsike clovers. Oats, of course, are somewhat less proteinous in their nature. Every good dairy farmer knows the feed value of green oats and of oats and peas; and "good wine needs no bush."

As pasture. Sheep or hogs are sometimes pastured on oats or on oats and peas, although this is rarely done in New England. It is said that in some sections success has been attained by turning sheep or hogs onto a piece where the peas and oat crop has ripened, that it is well liked, that rapid and economical meat production has been secured, and, finally, that the harvest of the crop and the manuring of the next crop has been done for nothing.

As hay. Oat hay and pea and oat hay are quite common factors nowadays in Vermont farming. If cut when the oats are in the "milk," or nearing the "dough" stage, or if a mixed hay before the pods ripen, the crop proves both palatable and nutritious. The mixed hay is relished especially by cows and sheep. It is cut and cured perhaps less easily than is grass hay; but the process is the same. As little handling as practicable is advisable. From 2 to 3 tons per acre should be secured.

The straw. Oat straw is commonly fed to horses, cattle and sheep as a maintenance ration. It nearly equals corn stover for this purpose. Stock can be "wintered over" very fairly if access is had to a straw stack and a little hay and grain are fed. Oat straw is less likely to waste than is corn stover, because of its better physical condition. The stock generally feed directly from the stacks, a wasteful practise since much is trampled under foot. It were better, if roughage rules

high in price, to feed in the manger or rack; but if roughage is cheap, the saving will hardly repay the labor outlay.

Oat straw is also used as bedding. It is a good absorbent, adds both bulk and humus to the manure and carries a considerable nitrogen and potash content. Its 25 pounds of potash to the ton is worth thinking about in these days of dearth.

GRAIN

Oats have been regarded as a mainstay in horse feeding for many generations. Indeed, some feeders know of almost no other grain in this connection. Their high protein content serves a necessary purpose in muscle construction and maintenance and in the development of the young. And their high crude fiber content is also an advantage in horse feeding, for the digestive system of the horse is not of the best and the complete mastication which the oats must receive tends to increase their digestibility. This very property renders them ill adapted to the feeding of swine. Practically the entire crop not used in oatmeal manufacture is fed to horses. While it is probably true that no other grain ration keeps them in better condition, perhaps none in quite as good condition, nevertheless equally satisfactory results may be attained with work horses if corn in part replaces oats. Indeed, brewers' dried grains, barley, bran and dried beet pulp have been used to advantage; and at the Ohio station a mixed clover and timothy hay was fed with ear corn and found quite as effective as a normal oats rations, the horses being in no wise injuriously affected nor was their endurance lessened. Moderate quantities of linseed meal, gluten feed or cottonseed meal mixed with corn has been fed in lieu of oats at less cost and with entire success. Oats are fed horses whole and rarely need be ground except for colts or animals with poor teeth. Musty grain should be avoided as well as new oats which are apt to induce diarrhoeal disturbance.

Oats, though well adapted to the purpose, usually cost too much to feed to cattle. They may be fed whole, crushed or ground, or in the form of corn and oat feed. Many proprietary feeds, so-called "dairy feeds," carry considerable quantities of light oats, oat hulls, etc., as is set forth on the label borne on the bag (see pages 27 to 34 of this bulletin). Oats may be fed to advantage to calves, lambs and ewes. If one is fattening stock, corn and oats will serve quite as well or better. The grain fed to youngsters should be ground. Oats are often used in poultry feeding, especially in conjunction with corn. A large share

of the proprietary poultry foods contain oats (see pages 35 to 40 of this bulletin); and, when sprouted in warm flats or greenhouses, are fed in the winter to hens as a digestive stimulant and as a means of furnishing green feed.

Oatmeal is a staple diet in northern Europe, throughout this country and elsewhere, especially in the form of "rolled oats," the product of passing the clean hulless kernels between heavy rollers. It is a cheap, palatable, digestible, serviceable cereal food; perhaps there is none better, if well and long cooked. Imperfectly cooked oatmeal is poorly digested because the gluten envelops considerable starch and protects it from the digestive fluids; whereas thorough cooking overcomes this mucilaginous tendency and frees the starch. Its high digestible protein and fat content, greater than that of any other cereal, accounts for its premier position in human dietaries.

BY-PRODUCTS

Several by-products of the oat kernel accumulate in the manufacture of oatmeal for human food. Some, such as oat shorts, oat bran, oat dust, are collected in such small quantities as to be commercially negligible; others, such as oat hulls, small oats, broken kernels, etc., have become important articles of commerce. The small oats and broken kernels have much food value and very properly are employed in the manufacture of feeding stuffs. The oat hulls, however, are relatively so lacking in digestible nutrients that their use in such a fashion as a rule is undesirable; or, stating the matter another way, they are commonly sold in the guise of proprietary goods at a price out of proportion to their food values.

REFERENCES

The following bulletins, published within the last 20 years by the Federal Department and by several Experiment Stations, deal with various phases of the growing of the oat crop. Most of them, if in print, can be had for the asking of the Department or the Station.

VARIETIES

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JUNE, 1916 BULLETIN 198

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Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FERTILIZERS

by J. L. HILLS, C. H. JONES and G. F. ANDERSON

CONCERNING TILLAGE

by R. T. BURDICK

BURLINGTON
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BULLETIN 198: COMMERCIAL FERTILIZERS

By J. L. Hills, C. H. Jones and G. F. Anderson

CONCERNING TILLAGE

By R. T. Burdick

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I. SUMMARY

II. The state fertilizer law provides that manufacturers shall state on each package the amounts of plant food it contains and shall make good in fact their claims; and it provides further that the Station shall determine whether or not in each case claims are made good.

Prior to this year the Stations of the North Atlantic States have established and used trade values in calculating the so-called "valuations." This year, owing to abnormalities in the trade in crude chemicals caused by wartime conditions, no trade values could be determined.

III. Results of inspection. The Station has drawn from dealers' stocks and analyzed 168 licensed brands, the output of 18 companies, all this year's goods. All the licensed brands but five were sampled and analyzed.

1. Quantity of plant food. Eighty-two percent of the brands met their guaranties. A few brands were not as good as they were said to be. The outcome on the whole is a fairly satisfactory one.

2. Quality of plant food. The quality of the crude stock used seemed to be beyond reproach. The organic nitrogen offerings were in the main satisfactory. A few brands contained potash. One hundred and sixty-two of the 168 brands carried appreciable amounts of mineral as well as of organic forms of nitrogen.

IV. Selling prices. The average selling price was $33.88. No valuation statement can be made this year owing to the anomalous situation now obtaining in the fertilizer trade as set forth on page 10.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 33 to 42, and 45 to 49.

VII. A special article dealing with the principles and practice of tillage appears on pages 50 to 83.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletin of the Station dealing with commercial fertilizers not only shall furnish the results of the analyses of these goods, but also may afford "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." The annual bulletin issued during the summer discloses the analyses of all the brands collected, shows their composition during the preceding two and the current years,[1] contains a general review of the state trade, makes statements as to the quantity and quality of the plant food sold in the various brands, considers the comparative value of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.[2]

These general matters are reviewed annually. In addition thereto there is presented yearly a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, has been continued for more than a dozen years, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language is used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99, 130, 143 and 154. These glossaries will be added to from time to time in the future whenever necessary. Anyone failing to grasp the meaning of the terms used should get bulletins 99, 130, 143 or 154 (if in print) and make use of their glossaries. They are free for the asking. The annual fertilizer bulletin is always thoroughly indexed.

The following statement outlines the "features" of the preceding bulletins:

1902. Bulletin 93. *Formulas for home mixing.*—56 pages. (Out of print).

1903. Bulletin 99. *Vermont's usage of fertilizers. Concerning fertilizer buying. Deficient plant food.*—88 pages. (Out of print).

[1] Omitted in 1915 and 1916 owing to the untoward conditions wrought by the European war, compelling manufacturers to reduce or omit their potash offerings.
[2] Omitted in 1916 since no trade values were established.

1904. Bulletin 108. *Classification of commercial fertilizers sold in Vermont. Farm manures.*—68 pages. (Out of print).

1905. Bulletin 116. *How, when and what to use.*—104 pages. (Out of print).

1906. Bulletin 123. *Concerning the purchase of plant food. The moisture relations of the soil.*—68 pages. (Out of print).

1907. Bulletin 130. *Soil biology in its relation to fertilization.*—144 pages. (Out of print).

1908. Bulletin 135. *A quarter of a century of fertilizer inspection. Soil deterioration and soil humus.*—128 pages. (Out of print).

1909. Bulletin 143. *The service of a fertilizer control. Soil physiography.*—144 pages.

1910. Bulletin 154. *Soil classifications and adaptations.*—112 pages.

1911. Bulletin 160. *Limes and liming.*—144 pages.

1912. Bulletin 165. *A survey of the peat and muck deposits of Vermont.*—104 pages.

1913. Bulletin 173. *The principles of land drainage.*—96 pages.

1914. Bulletin 182. *Irrigation.*—104 pages.

1915. Bulletin 190. *Crop rotation.*—80 pages.

These were written in 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914 and 1915; but in the main they are quite as applicable to the purchase and use of fertilizers in 1916 and in succeeding years as they were when first penned. The reader of this bulletin who does not own a 143, a 154, a 160, a 165, a 173, a 182, or a 190, and wants either or all of them, has but to ask to receive. Nos. 93, 99, 108, 116, 123, 130 and 135 are out of print.

Circular 7 on "Plant Food Combinations for Sundry Crops" contains a reprint of the more important formulas, etc., originally issued in bulletin 116.

Circular 10, issued last December "Concerning the Use of Commercial Fertilizers in 1916," deals with the changed situation wrought by war conditions. It is a 16-page pamphlet and can be had for the asking.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate ingredients used to manufacture the same, or * * * bone meal, land

plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.).

The law provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in water, and of available and total phosphoric acids." (Sec. 4976 P. S. as amended by No. 182 of the Acts of 1912).

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) "* * * shall annually * * * pay * * * a license fee of twenty dollars," which will permit "the sale of one brand of commercial fertilizer which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than one brand, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of one." "The fee (s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S. as amended by No. 169 of the Acts of 1910).

It provides that any person offering unguarantied, over-guarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool-waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the State Treasurer, and for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs. 4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.).

The full text of the law will be furnished on application.

LIST OF LICENSES

The following eighteen companies (or individuals) have paid licenses as required by law on the brands shown in the statements on pages 25 to 31 and in the tables on pages 33 to 42, and in the list of unsampled brands on the bottom of the next page. The sale within state limits of these brands and of these brands only is legal. All local agents, as well as intending purchasers, are warned against the

handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the required license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 2 Rector St., New York, N. Y.
Armour Fertilizer Works, 930-938 Equitable Building, Baltimore, Md.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 51 Chambers St., New York, N. Y.
Essex Fertilizer Co., 39 North Market St., Boston, Mass.
International Agricultural Corporation, Buffalo Fertilizer Works, 812 Marine Bank Building, Buffalo, N. Y.
Listers' Agricultural Chemical Works, Lister Ave., Newark, N. J.
Lowell Fertilizer Co., 40 North Market St., Boston, Mass.
National Fertilizer Co., 92 State St., Boston, Mass.
New England Fertilizer Co., 40A North Market St., Boston, Mass.
Parmenter & Polsey Fertilizer Co., 41 North Market St., Boston, Mass.
Reading Bone Fertilizer Co., 32-34 North Sixth St., Reading, Penn.
Rogers and Hubbard Co., Middletown, Conn.
F. S. Royster Guano Co., 1604-1614 Munsey Building, Baltimore, Md.
J. W. Sanborn, Pittsfield, N. H.
Sanderson Fertilizer and Chemical Co., Box 172, New Haven, Conn.
Virginia-Carolina Chemical Co., 24 Broad St., New York, N. Y.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 110 towns and villages in Vermont during the spring of 1916 and drew 525 samples from dealers' stocks, representing 168 distinct brands, the output of 18 companies or individuals licensed to sell in Vermont. A sample was secured of every brand which was licensed, except the following:

American Agricultural Chemical Co.'s Williams & Clark's Americus Ammoniated Bone Superphosphate, 1916.

National Fertilizer Co.'s Tobacco Special (Sulphate), 1916.

National Fertilizer Co.'s XXX Fish and Potash, 1916.

Listers' Agricultural Chemical Works, Celebrated Onion Fertilizer.

Listers' Agricultural Chemical Works, Valley Brand.

CONCERNING TRADE VALUES

It has been customary at this point each year to print the "schedule of trade values" agreed upon by the Experiment stations of New England, New York and New Jersey. These trade values were determined by carefully studying and averaging the prices at which fertilizer crude stock sold in our larger markets, such as New York and Boston, at retail for cash during the six months preceding March 1st. The wholesale prices were also carefully scanned. The system has worked well for a long series of years. Prices of standard goods have fluctuated more or less, but not so much as to prevent averages being struck which were within bounds of reason. Not so, however, in 1916. For example, nitrate of soda sold at approximately $45 a ton during the early months of the war; but it rapidly began to slant upwards, was quoted at $49 in August, 1915, at $65 in December and was recently bought delivered at Burlington in small quantities at $80. Sulphate of ammonia has increased from about $60 in 1914 to $80 at the present time. Everyone knows that beefsteak costs money nowadays and shortage of cattle means shortage of animal ammoniates. Cottonseed meal has sold of late at more than $40 a ton delivered in Vermont; yet it was quoted at southern shipping points last August at $23. Acid phosphate has shot up in price like an ascending rocket, costing twice what it did a year ago. And potash is almost as extinct as the dodo and sells at ten times what it once sold for. All this has been set forth in circular 10 issued in December, 1915.

It is quite evident that averages cannot be made with safety under such circumstances and that even if an attempt was made to establish trade values they would have no validity in view of the rapidly changing conditions now existing. Hence it was that, after careful consideration of the entire matter, it was unanimously voted at the annual spring meeting of the directors of the New England, New York and New Jersey stations to establish no trade values for 1916.

It is realized that some users of commercial fertilizers may miss the ready means of comparison heretofore afforded by the valuation system. If so, they must blame the Teutonic or the Allied governments—according to their predilections—and not the experiment stations.

III. RESULTS OF FERTILIZER INSPECTION

1. As to the Quantity of Plant Food

(a) COMPARISON OF GUARANTIES AND ANALYSES

The quality of the fertilizers sold in Vermont in 1916 has been on the whole good. Guaranties have been fairly well maintained, remarkably so in view of the unprecedented situation with which the trade has been forced to cope during the year. The proportion of deficiencies is normal. Most of the shortages are minor ones; and yet there have been a considerable number of cases where guaranties have been shaved so very closely that the margin of safety has been eliminated. With plant food at altitudinous prices the temptation to crowd the minimum guaranty has been great. In four cases brands were short of guaranty in respect to two ingredients; and since two of these brands contained no potash, these goods were deficient in all respects.

No trade values having been established for this year, this ready means of reckoning shortages cannot be resorted to. All forms of plant food stand in a sense on a parity, one being as good as another. There are a few brands decidedly deficient as thus measured, lacking respectively approximately 1⅛, ¾, ⅞ and ¾ percents of their promised plant food contents, equivalent to shortages of 9, 7, 7 and 7 percents of the amounts guarantied. The identity of these brands can be readily determined by reference to the tables of analyses.

The general situation is a good one. Faulty fertilizers, as judged by the comparison of promise and performance, are not very common, and the trade seems to be in a healthy condition. Indeed, comparison with the results attained in other states is on the whole a favorable one, since the proportion of guaranty maintenance seems better in Vermont than that commonly found elsewhere. Commercial fertilizers are shipped into Vermont earlier than into most of the other northern states. Whether to this fact or to other causes may be attributed the relatively small proportion of failures to furnish the promised plant food which usually obtains here cannot be said; but certain it is that, as judged by several years' control work, the Vermont farmer rarely buys a fertilizer of lower grade than is promised him.

The plant food shortages in the 33 deficients of 1916 were distributed as follows: Nitrogen, 8; available phosphoric acid, 24; potash, 5. Only eight of the 429 guaranties made on 168 brands by 18 manufacturers, or one in 54, were not made good within 0.50 percent of a

single ingredient; and only four were lacking to an extent materially greater than this; an excellent result.

The condensed results of 20 years' inspection of the Vermont trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1897	134	113	21	84	94
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	92	38	71	94
1906	130	110	20	85	98
1907	129	99	30	77	94
1908	130	92	38	71	95
1909	133	111	22	83	96
1910	152	138	14	91	100
1911	157	146	11	93	99
1912	182	156	26	86	98
1913	177	153	24	86	98
1914	185	153	32	83	97
1915	173	144	29	83	98
1916	168	137	31	82	..

Whenever guaranties were not made good the analytical work was repeated, and invariably recourse was had to other samples taken a second time from the original shipments, except in cases where the goods had been used prior to the attempt a second time to sample them. It should be remarked, however, that it was more difficult to do this in 1916 than usual, for shipments were belated owing to freight car embargoes and hence samples were drawn and analytical work begun several weeks later than usual. When results seemed open to question, other samples elsewhere drawn were analyzed. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were instituted with a view of minimizing error and standardizing results.

The following table shows the number of brands sold by the different companies licensed in Vermont, the number of guaranties (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good within the tolerance figures

long adopted at this Station, namely, 0.10 percent of nitrogen and 0.20 percent of available phosphoric acid or potash.

Name of company	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands deficient in total plant food
American Agricultural Chemical Co.	10	26	2	0
Bradley Fertilizer Co. branch	10	30	0	0
Cleveland Dryer Co. branch	3	9	0	0
Crocker Fert. and Chem. Co. branch	4	12	1	0
L. B. Darling Co. branch	2	6	0	0
Great Eastern Fertilizer Co. branch	4	12	1	0
Pacific Guano Co. branch	3	9	0	0
Quinnipiac Co. branch	3	9	0	0
Read Fertilizer Co. branch	3	9	0	0
Williams & Clark Fertilizer Co. branch	5	15	1	1
American Agricultural Chemical Co.—Total	47	137	5	1
Armour Fertilizer Works	9	24	2	1
Bowker Fertilizer Co.	12	32	1	0
Burlington Rendering Co.	6	13	1	0
Coe-Mortimer Co.	8	21	1	0
Essex Fertilizer Co.	6	13	0	0
International Agricultural Corporation, Buffalo Fertilizer Works	8	19	3	0
Listers' Agricultural Chemical Works	13	33	6	2
Lowell Fertilizer Co.	8	16	2	2
National Fertilizer Co.	4	12	0	0
New England Fertilizer Co.	6	13	0	0
Parmenter and Polsey Fertilizer Co.	8	17	0	0
Reading Bone Fertilizer Co.	7	15	4	2
Rogers and Hubbard Co.	6	13	3	1
F. S. Royster Guano Co.	9	22	4	1
J. W. Sanborn	3	6	4	3
Sanderson Fertilizer and Chemical Co.	3	9	0	0
Virginia-Carolina Chemical Co.	5	14	1	0
Total	168	429	37	13

Thirteen of the 18 companies contribute brands to the delinquent list. Four furnish a single brand each; two, 2; four, 3; two, 4; and one, 5 brands.

The range of composition and the closeness with which guaranties are met are displayed in the following table. The condition of affairs it discloses, a close hugging of the guaranties, has obtained for years, as appears in the second table, which shows the excess of the average analysis over the average guaranty for five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average only about seven

percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

MAINTENANCE OF GUARANTIES BY LICENSEES

	PERCENT GUARANTIED			PERCENT FOUND			
	Lowest	Highest	Average	Lowest	Highest	Average	Excess of average analysis over guaranty
Nitrogen	0.8	8.25	2.43	0.88	8.91	2.61	0.18
Total phosphoric acid	6.	16.	10.14	6.48	16.88	10.94	0.80
Available phosphoric acid	5.	13.	9.13	5.46	12.69	9.54	0.41
Potash	0.	2.	0.57	0.	2.43	0.55	—0.02
Selling price	$22.50	$60.00	$33.88				

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSES OVER GUARANTIES

	1912	1913	1914	1915	1916	Av'ge for 5 years
Nitrogen	0.21	0.20	0.17	0.31	0.18	0.21
Total phosphoric acid	1.02	0.82	0.85	0.89	0.80	0.88
Available phosphoric acid	0.29	0.41	0.44	0.53	0.41	0.42
Potash	0.47	0.54	0.29	0.14	—0.02	0.28
Valuation	$1.20	$1.90	$1.35	$1.36	$0.00	

While the above statement shows that the goods compare well on the average with the claims made for them, the tables on pages 33 to 42, and 45 to 49, as well as the statements on page 11, betray the fact that within this average lie concealed several deficiencies. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guarantied is not furnished to know that the "average" is good. It is for him to exercise care and avoid buying such goods. Yet it should be said that this year no seriously faulty fertilizers, so far as guaranty maintenance is concerned, were sold. Some years, however, very deficient goods have been offered.

(*b*) COMPARATIVE VALUES OF FERTILIZERS IN 1915 AND 1916

It has been customary at this point in the annual fertilizer bulletin to compare averages. Thus in 1914 at this point it was said that "of the 193 brands of commercial fertilizers which were sampled by the Station during 1913 and 1914, 169 have been selected for the purpose of instituting a comparison of the characters of the goods sold under these brand names in each of the two years. Only those brands have

been chosen which have been sampled both years." No such comparison can be made this year. Manufacturers were forced in 1915 by the potash situation decidedly to modify many of their brands as to their guaranties and in 1916 yet further changes had to be made. Many of the manufacturers have used new brand names or old ones slightly modified to meet this unprecedented situation. Others have sold their goods with unchanged brand names, but changed guaranties. It should be distinctly understood that this latter procedure is no crime, since the law does not and cannot control as to names. A manufacturer may, if he wishes, sell one year a high grade product named, let us say, Smith's Mighty Melon Maker, and the next year, using precisely the same brand name, sell the lowest of the low grades. *Caveat emptor;* it is for the buyer to beware, to watch guaranties and to buy accordingly.

The following statement shows the 1916 practice of the Vermont licensees.

New brand names used:

Armour Fertilizer Works,
F. G. Royster Guano Co.,
Virginia-Carolina Chemical Company.

"1916" placed after and made a part of each brand name, in order to distinguish it as a this year's formula:

American Agricultural Chemical Company,
Bowker Fertilizer Company,
Coe-Mortimer Company,
Listers' Agricultural Chemical Works,
National Fertilizer Company,
Sanderson Fertilizer and Chemical Company.

Former brand names used on most or all of the goods which often are quite unlike those heretofore sold under the same brand names:

Burlington Rendering Company,
Essex Fertilizer Company,
International Agricultural Corporation, Buffalo Fertilizer Works,
Lowell Fertilizer Company,
New England Fertilizer Company,
Parmenter and Polsey Fertilizer Company,
Reading Bone Fertilizer Company,
Rogers and Hubbard Company,
J. W. Sanborn.

A few typical examples of sales of brands similarly named but diversely guaranteed are shown herewith:

					VEGETABLE					
'14	guaranty:	2.46%	nitrogen;	7%	available	phosphoric	acid;	10%	potash	
'15	"	3.28%	"	8%	"	"	"	4%	"	
'16	"	4.1%	"	10%	"	"	"	0	"	
					CORN, GRAIN AND GRASS					
'14	guaranty:	3.28%	nitrogen;	6%	available	phosphoric	acid;	10%	potash	
'15	"	3.28%	"	8%	"	"	"	4%	"	
'16	"	3.28%	"	10%	"	"	"	1%	"	
					TOPDRESSING					
'14	guaranty:	5.7%	nitrogen;	6%	available	phosphoric	acid;	5%	potash	
'15	"	5.8%	"	6%	"	"	"	2%	"	
'16	"	5.8%	"	6%	"	"	"	0	"	
					POTATO AND TOBACCO					
'14	guaranty:	0.82%	nitrogen;	6%	available	phosphoric	acid;	7%	potash	
'15	"	0.82%	"	6%	"	"	"	4%	"	
'16	"	0.82%	"	12%	"	"	"	0	"	
					OATS AND TOPDRESSING					
'14	guaranty:	8.5%	nitrogen;	4.5%	available	phosphoric	acid;	8%	potash	
'15	"	8.5%	"	4.5%	"	"	"	4%	"	
'16	"	6%	"	6%	"	"	"	0	"	
					POTATOES AND CORN					
'14	guaranty:	3.3%	nitrogen;	7%	available	phosphoric	acid;	8%	potash	
'15	"	3.3%	"	8%	"	"	"	4%	"	
'16	"	3.3%	"	8%	"	"	"	0	"	

Let it be said again, it is no crime thus to modify formulas; but the ethics of such a procedure is open to question. The writer is frank to say that he believes that brand names ought to be altered whenever formulas are materially modified, that it is at once the honest and the expedient thing to do. Shakespeare's query "What's in a name" has pertinence in this connection.

(*c*) COMPARATIVE VALUE OF FERTILIZERS FROM 1897 TO 1916

The next table shows the average composition of the fertilizers as analyzed during the last 20 years. Every brand tested each year is included in the comparison, each one being given equal value. It is well understood that this is not strictly a correct method of calculation, but it is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods in the past have sold slowly, and, unfortunately, low grade brands as a rule readily, the actual average as used is probably somewhat lower than that shown in the table. Yet the evidence in hand indicates a rapidly lessening usage of low grades and a larger usage of medium and high grades.

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1897 TO 1916

Year	Number of brands	Nitrogen	PHOSPHORIC ACID					Potash	Average ton selling price	Valuation each year's trade values	Selling price exceeds valuation	Selling price exceeds valuation, (percent)	Value of plant food received for a dollar (cts.)
			Soluble	Reverted	Insoluble	Total	Available						
1897	134	2.12	5.34	3.68	2.23	11.25	9.02	3.43	$29.19	$19.47	$ 9.72	50	67
1898	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81	29.04	17.86	11.18	63	61
1899	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10	28.75	17.39	11.36	65	60
1900	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80	28.73	18.08	10.65	59	63
1901	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33	28.75	19.44	9.31	48	68
1902	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21	28.23	20.18	8.05	40	71
1903	111	2.02	5.13	3.42	2.50	11.05	8.55	3.79	28.25	18.59	9.66	52	66
1904	118	1.98	5.20	3.19	2.38	10.77	8.39	3.95	29.00	18.47	10.53	57	64
1905	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18	29.62	19.04	10.58	56	64
1906	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37	29.52	19.38	10.14	52	66
1907	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65	30.57	21.21	9.36	45	69
1908	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58	31.24	20.75	10.49	51	66
1909	133	2.08	5.25	3.07	2.21	10.53	8.32	4.70	31.43	18.84	12.59	67	60
1910	152	2.12	5.50	2.86	1.53	9.89	8.36	4.99	31.45	20.57	10.88	53	65
1911	157	2.06	5.69	2.60	1.56	9.85	8.29	4.94	31.41	19.53	11.88	61	62
1912	182	2.19	4.99	2.92	1.75	9.66	7.91	5.55	32.03	20.09	11.94	59	63
1913	177	2.37	4.69	3.16	1.37	9.21	7.84	5.96	32.64	21.24	11.40	54	65
1914	185	2.32	4.68	3.19	1.51	9.38	7.87	5.77	32.53	20.35	12.18	60	63
1915	173	2.48	4.81	3.85	1.43	10.09	8.66	3.00	33.06	20.64	12.42	60	59
1916	168	2.61	5.12	4.42	1.40	10.94	9.54	0.55	33.88	....	....	..	..

It ought to be remarked at this point that neither this table, nor the discussion of the table, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made a dozen or more years ago to estimate the relative usage of the different grades, but without much success. No data are available that are trustworthy, while if one appeals to the individual judgment of those who are in close touch with the trade the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used during the years immediately preceding 1915 at approximately 2.1 percent nitrogen, 8.5 percent available phosphoric acid, and 3.7 to 4 percent potash; in 1915 at approximately 2.3 percent nitrogen, 8.7 percent available phosphoric acid, and 2.5 percent potash; and this year at approximately 2.5 percent nitrogen, 9.5 percent available phosphoric acid and either a 0.95 percent potash content or none whatever.

The average commercial fertilizer sold in Vermont in 1914 contains 0.25 percent more nitrogen, 0.50 percent less available phosphoric acid and a percent more potash than the average sold in the decade

previous to 1912. The 1915 goods as compared with last year's were 0.2 percent higher in nitrogen, 0.8 percent higher in available phosphoric acid and 2.75 percent lower in potash; and the 1916 goods were increased 0.1 percent in nitrogen and 0.9 percent in available phosphoric acid over the 1915 goods, and contained but one-sixth as much potash. Indeed, as compared with the average goods sold in 1912 to 1914 they contained one-eighth more nitrogen and one-sixth more available phosphoric acid; but as an offset to these increments they contained nine-tenths less potash.

The increase in the average of the ten years, 1905-1914, as compared with those of previous years is due to the high grade of certain goods sold for the first time in 1905, and to the entry in each of several years since, and especially during 1912-1914, of a number of very high grade goods. There are 50 more brands sold in Vermont today than were offered five years ago. This change in average quality is doubtless more apparent than real, for the newcomers inevitably are not at the outset as widely sold as are the old-timers. A survey of the last table indicates that there has been on the whole an up-grading in the last 20 years in the character of the goods used by Vermont farmers. Indeed there seem to be four periods of 4, 6, 7 and 3 years respectively, wherein there are to be found somewhat wide variations in the plant food contents of the average goods, particularly in phosphoric acid and potash as is shown in the following table:

1895-98	nitrogen 2.19,	available phosphoric acid 8.75,	potash 3.60
1899-04	nitrogen 2.07,	available phosphoric acid 8.51,	potash 4.06
1905-11	nitrogen 2.08,	available phosphoric acid 8.25,	potash 4.63
1912-14	nitrogen 2.29,	available phosphoric acid 7.87,	potash 5.76
1915	nitrogen 2.48,	available phosphoric acid 8.66,	potash 3.00
1916	nitrogen 2.61,	available phosphoric acid 9.54,	potash 0.55

2. As to Quality of Plant Food

(*a*) sources of plant food in licensed fertilizers

The table on page 14 as well as those on pages 33 to 42 show wide ranges in composition, amounts of nitrogen varying from 0.88 to 8.91 percent, of available phosphoric acid from 5.46 to 12.69 percent, and of potash from zero to 2.43 percent. These figures alone, however, do not tell the whole story or, indeed, much of the story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food purveyed in the various brands is derived.

NITROGEN

In all but 6 of the 168 brands, nitrogen as nitrate of soda or sulphate of ammonia was present in appreciable amounts. Doubtless the fact that mineral nitrogen is now cheaper and more plentiful than is organic nitrogen explains its freer usage. Time was, not long ago, when the ratio of mineral to organic nitrogen was much less than it is today in the goods sold in Vermont, and when a large share of the goods contained neither nitrate nor ammonia salts. The amounts found in this year's goods vary from 0.07 to 7.12 percent, averaging 1.32 percent or 51 percent of the total nitrogen present in the brands carrying this ingredient, a very different situation than formerly obtained. Under certain circumstances and for certain purposes mineral nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available but is more easily lost by leaching. One cannot help but shudder to think of the great losses which must have occurred during this June of torrential downpours. Speaking broadly, however, the presence of mineral nitrogen in commercial fertilizers is to be favored for most of the purposes for which such goods are used in Vermont. It is an open question, however, whether manufacturers are not going too far in this matter. Fifty to 60 percent of nitrogen in mineral forms in some seasons may be a somewhat larger proportion than can be used to good advantage. An over-supply may be present at the outset and, following heavy rains, an under-supply during late July and August; yet on the other hand it is but fair to admit that manufacturers are often at their wit's end in attempting to secure an adequate supply of organic nitrogen of good grade. The usage of commercial fertilizers in this country is increasing by leaps and bounds. In 1900, 2,200,000 tons were produced; in 1913, more than 6,800,000 tons; and the increased crop acreage of 1915 doubtless absorbed fully 7,500,000 tons. Yet in the face of this situation the supply of many forms of organic nitrogen is shrinking both relatively and actually. Just what will happen a decade hence, just what manufacturers and farmers will do for organic nitrogen, is not easy to predict.

All the brands which carry nitrogen contain more or less organic nitrogen, derived doubtless as a rule from standard animal and vegetable ammoniates, such as dried blood, meat meal, fish scrap, tankage, etc. Probably tankage is at present its main source in a large proportion of the brands.

AVAILABILITY OF ORGANIC NITROGEN

In the tables of analyses, pages 33 to 42, appear tabulated data setting forth the character of the organic nitrogen used in the various brands offered for sale, with a view of indicating its serviceability to crop growth. This Station for nearly 20 years has thus "kept tab" on the quality of the organic nitrogen which was used in the several brands offered for sale. Long before it seemed advisable to print its analytical results it formed an opinion in many cases of the character of the organic nitrogen used in the fertilizers sold to Vermont farmers. It did not hesitate by correspondence and by personal interview to question the character of the organic nitrogen used in certain brands, and in times past not infrequently found its queries to be justified by facts, either directly acknowledged or at least not gainsaid by the manufacturers. Its long experience with the alkaline permanganate method of determining organic nitrogen availability, the long series of analytical results accumulated in its files during the past 18 years, the work done by other stations in this section of the country using the same method, have served to give it confidence in the essential accuracy of its findings.

The nitrogen contents of a fertilizer are now stated in the analytical tables in the following terms: Nitrogen in nitrates; nitrogen in ammonia salts; water soluble organic nitrogen; insoluble organic nitrogen; total nitrogen.

1. *Nitrogen in nitrates.* The percentage of nitrogen derived from nitrate of soda, a soluble mineral form of nitrogen immediately available to plant growth.

2. *Nitrogen in ammonia salts.* The percentage of nitrogen derived from sulphate of ammonia, a high grade gas-house or coke-oven by-product[1]; a mineral form of nitrogen readily available to plant growth.

3. *Water soluble organic nitrogen.* The percentage of nitrogen derived from organic sources which is soluble in water.[1] The presumption is that most organic nitrogen soluble in water is likely on that account to be relatively available to plant growth.

4. *Insoluble organic nitrogen.* The percentage of such organic nitrogen as is not soluble in water.

The organic nitrogen in the 168 brands analyzed in 1916 and reported upon in this bulletin seems to be sufficiently good quality to

[1] The nitrogen derived from calcium cyanamid would appear either here or as "water soluble organic nitrogen," or both, according to circumstances.

warrant passing in all but four cases. These four samples were submitted not only to be the standard alkaline permanganate but also to the neutral permanganate treatment, in order beyond peradventure to fix the status of their organic nitrogen contents. The analytical results are appended:

		Nitrogen as ammonia	Water soluble organic nitrogen	Water insoluble organic nitrogen	Total nitrogen	Guaranteed	Activity of insoluble nitrogen	
							Method	
							Alkaline permanganate	Neutral permanganate
		%	%	%	%	%	%	%
H 4	Listers' Plant Food.....	0.14	0.35	0.60	1.09	0.82	47	62
J 6	Royster's Cuckoo	0.48	0.05	0.42	0.95	0.82	48	73
J 9	Royster's Drillwell	0.79	0.58	1.23	2.60	2.47	48	83
J 11	Royster's Logical Compound	0.41	0.50	0.77	1.68	1.65	45	75

It would appear that 56, 44, 47 and 46 percents respectively of the total nitrogen and 63, 89, 68 and 60 percents respectively of the organic nitrogen of these four brands were derived from organic materials of low activity. The results, secured by the use of both the alkaline and the neutral permanganate methods, clearly indicate this condition. Furthermore a considerable proportion of the organic constituents were separated from the inorganic portions of these several samples, carbon tetrachlorid being used for the purpose,[1] and the nitrogen contents and activities of these separates were determined. The results are set forth in the following table. It will be observed that they fully substantiate the original findings.

		Total nitrogen	Insoluble nitrogen	Activity of insoluble nitrogen by the alkaline permanganate method
		%	%	%
H 4	Lister's Plant Food	3.78	2.74	36
J 6	Royster's Cuckoo	4.70	3.12	33
J 9	Royster's Drillwell	5.90	3.79	46
J 11	Royster's Logical Compound	5.62	3.40	36

[1]Journ. Ind. and Eng. Chem., Vol. 6, No. 7, p. 508 (1914).

PHOSPHORIC ACID

Some companies furnish more total phosphoric acid in available form than do others; some, more of the water soluble relative to the citrate soluble or reverted than do others. Water soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumina phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as serviceable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 55 percent to 97 percent. The proportions of available phosphoric acid found to be in a water soluble form varied from 2 to 80 percent. Grouped according to their manufacture it was found that extremes for available in total were 68 and 92 percents, for water soluble in available 31 and 70 percents. In other words the average goods made by one firm carried 92 percent of the total phosphoric acid in available form, while those made by another firm furnished but 68 percent in that shape, the remainder ranging between. Similarly, on the average 70 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 31 percent was thus soluble in the average goods of another firm. The low availability seems to be due in certain cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause, to imperfectly cut phosphate rock, to the age of the goods, to the use of agriculturally inferior forms of phosphoric acid, or to other causes does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, very rarely, nitrate. Practically sulphate of potash does not enter into the Vermont fertilizer trade nowadays. The asterisk (*) appears in connection with the potash figures in the column thus headed on pages 42 and that one only, sulphate of potash being

found to be present; where this sign does not appear, the potash was derived from muriate or kainit, or else a sufficiency of chlorin was present in other combinations to mark the presence of sulphate and entirely to nullify its good effects, if any such there be.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for 20 years; but for the reasons set forth on page 10 such a relationship cannot be established this year. However, some statements may be made as to the relative costs.

The brands may be classified as to selling price as follows:

	Number of brands	Percentage of total	Average selling price
Low priced, selling at $31 or below.....	48	29	$28.42
Medium priced, selling from $31.50 to $34.50	66	39	33.00
High priced, selling for $35 or more.....	54	32	39.84

What have fertilizers cost during this year of stress and strain as compared with previous years, when conditions were normal?

The following table sets forth this situation:

	Average	Low priced	Medium priced	High priced
Selling price 1914	$32.53	$26.08	$30.64	$39.66
Selling price 1915	33.06	26.46	31.84	40.35
Selling price 1916	33.88	28.42	33.00	39.84
Increase or decrease 1915 over 1914	+0.53	+0.38	+1.20	+0.69
Increase or decrease 1916 over 1914	+1.35	+2.34	+2.36	+0.18

It appears:

1. That the average 1915 goods cost a half dollar and the average 1915 goods nearly $1.50 more than the average ante-bellum fertilizer.

2. That the lower grades cost but little more in 1915 than in 1914 but that their price was raised nearly $2.50 in 1916.

3. That the medium priced brands were increased in price about $1.25 in 1915 and almost as much more in 1916.

4. That the high priced fertilizers were increased about 75 cents in 1915 but hardly at all in 1916 as compared with 1914. However,

these goods suffered more—much more—than their weaker sisters in the debasement of their quality on account of potash shortage.

How was the potash distributed in the 1916 goods?

Low priced	48 brands	19 contained 1 percent	30 percent
Medium priced	66 brands	37 contained 1 percent	56 percent
High priced	54 brands	35 contained 1 percent	
		2 contained 2 percent	69 percent

A third of the lower grades, rather more than half the medium grades and two-thirds the higher grades carried potash.

The 1916 goods sold in Vermont were, so far as their potash contents are concerned, of three sorts. A little more than half of them contained one percent of potash; a little less than half no potash whatever; and two brands were guaranteed to carry two percent of this rare ingredient. It is a pertinent question to ask what manufacturers charged for one percent of potash? Exact comparisons are not possible, because fertilizers cost more at some points in Vermont than at others, owing to differences in freight rates; but, speaking broadly, it seems safe to say that about $2.75 was charged in the lower grades and $4.50 in the medium and higher grades, or from about 14 to 23 cents a pound. It is quite safe to say that this modicum of potash was not worth the price asked for it. Had there been several percent present conceivably, not probably, it might have been worth 14 cents to the farmer; but one percent is an almost negligible quantity.

ELEMENTS DETERMINING THE PRICE OF A COMMERCIAL FERTILIZER

Many elements enter into the determination of the cost of a commercial fertilizer as it is usually bought by the farmer from a local dealer in relatively small amounts and on time. They include:

1. *Assembling.* The original wholesale cost of the crude stocks or ingredients to the manufacturer, who secures nitrate of soda from Chili, potash salts from Germany, pyrites for the manufacture of sulphuric acid from many localities in this and other countries, phosphate rock from Florida, South Carolina or Tennessee, sulphate of ammonia from Europe or from various points in this country, organic ammoniates from all sorts and conditions of places, from near at hand and from the ends of the earth. This original cost must of course cover the cost of mining and manufacture, of freight to the factory and the overhead charges incident to manufacture, shipping and jobbing.

2. *Mixing.* The cost of mixing, including the manufacture of sulphuric acid, the expense of grinding phosphate rock, bones, etc.,

the commingling in the requisite proportions of the several ingredients, their storage until dry, their regrinding, bagging and loading.

3. *Mixing.* The overhead cost on the charges which are necessarily connected with the assembling and the mixing of the plant food, covering such items as interest on investment, insurance, taxes, depreciation of the manufacturing plant, certain office charges, etc.

4. *Transportation.* Freight from factory to railroad station.

5. *Selling.* The overhead costs and charges inevitably connected with the sale of mixed fertilizers, covering such items as commissions to agents and dealers, interest charges on long credits, bad debts, advertising, and, finally, profits.

V. OBSERVANCE OF THE FERTILIZER LAW

LIST OF LICENSED COMMERCIAL FERTILIZERS

The following companies have paid licenses on the 168 brands specified on this and the next few pages, being the entire number of licensed brands save the five listed on page 9, which were not found on sale by the station sampling agents. This list also shows the names and addresses of the parties from whose stocks the samples were drawn and the laboratory sample numbers referring to the analyses on pages 33 to 42.

AMERICAN AGRICULTURAL CHEMICAL Co., 2 Rector St., New York.

K 3 *AA Potato Grower, 1916;* W. F. Cunningham, St. Albans.
A 1 *Ammoniated Fertilizer A;* H. E. Currier, Concord.
A 2 *Ammoniated Fertilizer AA;* E. P. Hayes, Arlington.
A 3 *Ammoniated Fertilizer AAA;* W. H. Gray, Orleans.
A 4 *Ammoniated Fertilizer AAAA;* E. J. Davis, Chester.
K 2 *General Crop Grower, 1916;* A. V. Fisher, Middlebury.
A 5 *Grass and Lawn Topdressing, 1916;* Fairview Farm, North Bennington.
A 6 *High Grade Fertilizer, 1916;* L. J. Mills, Groton.
K 1 *Special Grass and Garden Mixture, 1916;* H. N. Gray, Cambridge.
A 7 *Topdresser, 1916;* H. D. Dunn, Brownsville.

(Bradley Fertilizer Co. Brands)

A 12 *Bradley's Circle Brand Bone and Potash, 1916;* A. W. Clark, Marshfield.

A 8 *Bradley's Complete Manure for Corn and Grain, 1916;* Hoyt & McAllister, Williamstown.

A 9 *Bradley's Complete Manure for Potatoes and Vegetables, 1916;* Jones & Berry, Montpelier.

A 10 *Bradley's Complete Manure for Topdressing Grass and Grain, 1916;* N. M. Nelson, Barre.

A 11 *Bradley's Corn Phosphate, 1916;* Valley Grain Co., Brattleboro.

A 13 *Bradley's Eclipse Phosphate, 1916;* A. A. Pinney, Passumpsic.

A 14 *Bradley's High Grade Potato and Root Special, 1916;* Valley Grain Co., Brattleboro.

A 16 *Bradley's Potato Fertilizer, 1916;* D. I. Grapes, St. Johnsbury Center.

A 15 *Bradley's Potato Manure, 1916;* H. W. Myers, Bennington.

B 1 *Bradley's XL Superphosphate of Lime, 1916;* H. W. Myers, Bennington.

(Cleveland Dryer Co. Brands)

B 4 *General Crop Fertilizer, 1916;* Barber Grain Store, Windsor.

B 3 *Potato Phosphate, 1916;* L. J. Mills, Groton.

B 2 *Superphosphate, 1916;* Fairview Farm, North Bennington.

(Crocker Fertilizer and Chemical Co. Brands)

G 11 *Ammoniated Corn Phosphate, 1916;* F. L. Fish, Randolph.

B 6 *New Rival Ammoniated Superphosphate, 1916;* A. Lawrence, Derby.

B 5 *Potato, Hop and Tobacco Fertilizer, 1916;* M. S. Hastings, Corinth.

G 12 *Special Potato Fertilizer, 1916;* F. L. Fish, Randolph.

(Darling Fertilizer Co. Brands)

B 7 *Farm Favorite, 1916;* G. C. Moulton, Corinth.

B 8 *General Fertilizer, 1916;* G. C. Moulton, Corinth.

(Great Eastern Fertilizer Co. Brands)

B 9 *General Fertilizer, 1916;* A. St. Francis, Derby Center.

B 10 *High Grade Potato Fertilizer, 1916;* E. C. Norton, Wallingford.

B 11 *Northern Corn Special, 1916;* H. E. Currier, Concord.

B 12 *Potato Manure, 1916;* H. D. Dunn, Brownsville.

(Pacific Guano Co. Brands)

B 14 *Nobsque Guano, 1916;* M. Joselyn, Newport.

L 6 *Potato Special, 1916;* E. C. Place, Huntington.

B 13 *Soluble Pacific Guano, 1916;* Frank Ward, West Burke.

(Quinnipiac Co. Brands)

B 15 *Corn Manure, 1916;* W. B. Foster, South Londonderry.
K 13 *Market Garden Manure, 1916;* Valley Grain Co., Brattleboro.
B 16 *Potato Phosphate, 1916;* Vermont Soldiers' Home, Bennington.

(Read Fertilizer Co. Brands)

J 4 *Farmers' Friend Superphosphate, 1916;* O. Phoenix, Swanton.
C 1 *High Grade Farmers' Friend Superphosphate, 1916;* L. J. Mills, Groton.
J 3 *Practical Fertilizer, 1916;* O. Phoenix, Swanton.

(Williams & Clark Fertilizer Co. Brands)

C 3 *Americus Corn Phosphate, 1916;* D. E. Bushnell, Bennington.
C 2 *Americus High Grade Special for Potatoes and Root Crops, 1916;* Valley Grain Co., Brattleboro.
C 4 *Americus Potato Manure, 1916;* Frank Ward, West Burke.
K 15 *Royal Bone Phosphate, 1916;* C. A. Chapman, Ferrisburg.
C 5 *Special Prolific Crop Producer;* Jones & Berry, Montpelier.

ARMOUR FERTILIZER WORKS, 930-938 Equitable Bldg., Baltimore, Md.

K 7 *Five-Eight-One;* M. A. Nelson, Montpelier.
C 9 *Four-Eight-One;* M. A. Nelson, Montpelier.
K 4 *Four-Eight-Zero;* Ralph Denio, Bristol.
K 5 *One and a half-Nine-Zero;* E. O. Mead, Hinesburg.
C 8 *Three-Eight-One;* A. J. Dewey, Bennington.
K 6 *Two and one-half-Eight-Two;* W. P. Abbott, Bellows Falls.
C 7 *Two-Eight-One;* Fred Potter, Pownal.
C 6 *Two-Eleven-Zero;* M. A. Nelson, Montpelier.
C 10 *Wheat, Corn, Oats Special;* M. A. Nelson, Montpelier.

BOWKER FERTILIZER CO., 43 Chatham St., Boston, Mass.

H 15 *All Round Fertilizer, 1916;* Burlington Flouring Co., Burlington.
C 11 *Brighton Phosphate;* A. Goyette, North Troy.
E 4 *Corn Phosphate, 1916;* Powell & Comings, Richford.
H 16 *Farm and Garden Phosphate, 1916;* N. N. Morse & Son, Randolph.
E 3 *Hill and Drill Phosphate, 1916;* —— Martin, Bradford.
C 12 *Potato Phosphate, 1916;* H. E. Currier, Concord.
C 13 *Stockbridge General Crop Manure, 1916;* E. S. Garfield, South Londonderry.

C 14 *Stockbridge Cereal Manure without Potash, 1916;* M. A. Nelson, Montpelier.

H 9 *Stockbridge Early Crop Manure, 1916;* V. Badger, Alburg.

C 15 *Superphosphate with Ammonia, 1%;* George Shorey & Son, Lyndonville.

C 16 *Superphosphate with Ammonia, 2%;* H. E. Currier, Concord.

E 2 *Sure Crop Phosphate, 1916;* L. F. Fortney, Plainfield.

BURLINGTON RENDERING CO., North Ave., Burlington, Vt.

D 1 *Animal Fertilizer;* F. A. Crane, Danville.

D 2 *Grain Fertilizer;* A. St. Francis, Derby Center.

G 10 *Grass Fertilizer;* L. L. Allen, Craftsbury.

D 3 *Potato Fertilizer,* T. E. Meade, Guilford.

D 4 *Special Fertilizer;* L. L. Allen, Craftsbury.

D 5 *Vegetable Fertilizer;* W. B. Fifield, Plainfield.

THE COE-MORTIMER CO., 51 Chambers St., New York, N. Y.

F 1 *Columbian Corn and Potato Fertilizer, 1916;* C. J. Maxham, Woodstock.

E 5 *Gold Brand Excelsior Guano, 1916;* R. C. Eastman, Bradford.

F 3 *High Grade Ammoniated Superphosphate, 1916;* F. Terrent, Highgate.

E 6 *New Englander Special, 1916;* Adams & Davis, Chester.

F 4 *Red Brand Excelsior Guano, 1916;* M. A. Nelson, Montpelier.

F 2 *Standard Potato Fertilizer, 1916;* C. J. Maxham, Woodstock.

J 15 *Universal Fertilizer, 1916;* W. S. Brown, Underhill.

F 5 *XXV Ammoniated Phosphate, 1916;* E. Farrar, West Rupert.

ESSEX FERTILIZER CO., 39 N. Market St., Boston, Mass.

E 7 *Grain, Grass and Potato Fertilizer;* W. S. Wright, Lyndon Center.

H 7 *Manure for Corn, Grain and Grass;* H. E. Shaw, Stowe.

E 8 *Market Garden and Potato Manure;* Frank Thayer, Brattleboro.

F 6 *Potato Grower;* Hawthorne & Boynton, Bristol.

H 8 *Special Potato, Grass and Lawn;* H. E. Shaw, Stowe.

E 9 *XXX Fish Fertilizer;* I. H. Carr, Hardwick.

INTERNATIONAL AGRICULTURAL CORPORATION,

BUFFALO FERTILIZER WORKS, 812 Marine Bank Bldg., Buffalo, N. Y.

D 6 *Buffalo Ammoniated Phosphate;* Henry Ward, Arlington.

F 8 *Buffalo Economy;* C. Goodrich, Richmond.

D 7 *Buffalo Farmers' Choice;* A. H. Winslow, Bennington.
D 8 *Buffalo General Favorite;* Edward Foss, Plainfield.
D 9 *Buffalo High Grade Manure;* Edward Foss, Plainfield.
F 7 *Buffalo New England Special;* Russell Young, Bristol.
D 10 *Buffalo Top Dresser;* Edward Foss, Plainfield.
D 11 *Buffalo Vegetable and Potato;* A. H. Winslow, Bennington.

LISTERS' AGRICULTURAL CHEMICAL WORKS, Lister Ave., Newark, N. J.

K 8 *Atlas Brand Fertilizer, 1916;* M. A. Nelson, Montpelier.
F 16 *Corn and Potato Fertilizer, 1916;* G. B. Brown, Brownsville.
K 9 *Crescent Ammoniated Superphosphate, 1916;* B. F. Whelden's Sons, Ludlow.
H 5 *Excelsior Guano, 1916;* Sargent, Osgood & Roundy, Randolph.
G 16 *High Grade Special for Spring Crops, 1916;* W. A. Fields, East Hardwick.
H 3 *High Grade Topdresser, 1916;* C. J. Greene, Waitsfield.
H 4 *Plant Food, 1916;* H. O. Holt, Richford.
G 15 *Potato Manure, 1916;* H. H. Fisk, Waitsfield.
G 13 *Revised Vermont Corn and Potato Fertilizer, 1916;* B. D. Piper, Greensboro.
K 16 *Special Potato Fertilizer, 1916;* Sargent, Osgood & Roundy, Randolph.
H 1 *Standard Grass Fertilizer, 1916;* C. S. Brush, Jeffersonville.
G 14 *Success Fertilizer, 1916;* H. O. Holt, Richford.
H 2 *Superior Ammoniated Superphosphate, 1916;* H. H. Fisk, Waitsfield.

LOWELL FERTILIZER CO., 44 N. Market St., Boston, Mass.

F 9 *Animal Brand for All Crops;* D. G. Sargent, St. Johnsbury Ctr.
F 10 *Bone Fertilizer for Corn, Grain, Grass and Vegetables;* J. Loomis, North Bennington.
F 11 *Corn and Vegetable Manure;* E. F. Cleveland, Moscow.
F 12 *Empress Brand for Corn, Potatoes and Grain;* J. Allen, South Hero.
F 13 *Potato Manure;* H. W. Myers, Bennington.
H 6 *Market Garden, Special Grass and Lawn;* E. F. Cleveland, Moscow.
F 14 *Potato Phosphate;* H. A. McClarens, Barnet.
F 15 *Sterling Phosphate;* A. B. Tucker, Waitsfield.

NATIONAL FERTILIZER CO., 92 State St., Boston, Mass.

E 10 *Eureka Potato Fertilizer, 1916;* J. F. Maley, East Putney.
J 16 *Potato Phosphate, 1916;* O. L. Cobb, Bridgewater.
E 11 *Special Complete Fertilizer, 1916;* Andrew Thorburn, Norwich.
E 12 *Universal Fertilizer, 1916;* Andrew Thorburn, Norwich.

NEW ENGLAND FERTILIZER CO., 42 N. Market St., Boston, Mass.

K 11 *Complete Manure for Potatoes and Vegetables;* S. L. Stevens, Northfield.
K 12 *Corn and Grain Fertilizer;* S. L. Stevens, Northfield.
K 10 *Corn Phosphate;* E. Carlton, Barre.
H 12 *Potato Fertilizer;* B. W. Earle, Chester.
H 10 *Potato and Vegetable;* W. A. Sinclair, Johnson.
H 11 *Superphosphate for All Crops;* E. P. Osgood, Newfane.

PARMENTER & POLSEY FERTILIZER CO., 40 N. Market St., Boston, Mass.

D 12 *Corn and Grain Fertilizer;* Henry Osgood, Danville.
L 5 *Grain Grower;* E. Taylor, Orleans.
D 13 *Plymouth Rock Brand Fertilizer for All Crops;* A. W. Newton, Wallingford.
L 3 *Potato and Vegetable;* Edson Holden, South Barre.
D 14 *Potato Fertilizer;* E. Taylor, Orleans.
L 1 *Potato Phosphate;* W. H. Vaughn, Middlesex.
L 4 *Special Potato;* Edson Holden, South Barre.
L 2 *Star Brand Superphosphate;* G. Gates, Essex Center.

READING BONE FERTILIZER CO., 32-34 North 6th St., Reading, Pa.

E 13 *All Crop Special;* T. J. Hayes, Arlington.
E 16 *Farmers' Tankage and Potash for Corn, Grain and Grass;* A. Sears, Richford.
H 14 *Never Fail Crop Grower;* I. Goodnow, St. Albans.
H 13 *Prize Winner;* S. Strong, Waitsfield.
E 14 *Special Grain and Grass Producer;* Ivan DeRosie, Woodstock.
E 15 *Potato and Tobacco Manure;* W. W. Bryant, Troy.
L 7 *Truck, Fruit, Tree, Vine, Potato and Tobacco Grower;* W. A. Soule, Alburg.

ROGERS & HUBBARD CO., Middletown, Conn.

G 1 *All Soils—All Crops Phosphate;* E. S. Tewksbury, Randolph.
G 2 *Complete Phosphate;* A. W. Allen, Barre.
G 3 *Fertilizer for Oats and Topdressing;* A. W. Allen, Barre.

G 4 *Potato Phosphate;* W. W. Goodnow, Brandon.
G 5 *Soluble Corn and General Crops Manure;* J. T. Barker, Hinesburg.
J 5 *Soluble Potato Manure;* J. H. Hathaway, Brandon.

F. S. ROYSTER GUANO CO., 1255 Calvert Bldg., Baltimore, Md.

J 6 *Cuckoo Crop Grower;* P. Mullen, Richford.
J 7 *Curfew Ammoniated Superphosphate;* Don Camp, South Barre.
J 8 *Defender Fertilizer;* O. Howard, South Barre.
J 9 *Drillwell Phosphate;* Don Camp, South Barre.
J 14 *Goodwill Ammoniated Superphosphate;* A. J. Clark, Sutton.
J 10 *Log Cabin Guano;* Don Camp, South Barre.
J 13 *Innovation Ammoniated Superphosphate;* W. H. Hill, Colchester.
J 11 *Logical Compound;* Morrow Bros., Swanton.
J 12 *Penguin Ammoniated Superphosphate;* H. C. Royce, Sheldon Springs.

J. W. SANBORN, Pittsfield, N. H.

L 8 *Prof. Sanborn's Chemical Fertilizer for Grass and Grain;* Ward Lumber Co., Moretown.
J 2 *Prof. Sanborn's Chemical Fertilizer for Use in Hill and Drill;* H. C. Farnsworth, Milton.
J 1 *Prof. Sanborn's Chemical Fertilizer for Potatoes and Corn;* H. C. Farnsworth, Milton.

SANDERSON FERTILIZER AND CHEMICAL CO., Box 172, New Haven, Conn.

G 6 *Atlantic Coast Bone, Fish and Potash, 1916;* Ralph Wood, Essex Center.
G 7 *Corn Superphosphate, 1916;* W. A. Renfrew, Wells River.
G 8 *Potato Manure, 1916;* Martin Lee, Castleton.

VIRGINIA-CAROLINA CHEMICAL CO., 24 Broad St., New York, N. Y.

D 15 *Ammoniated Bone Phosphate for all Crops;* A. W. Clark, Marshfield.
G 9 *High Grade Corn and Vegetable Compound;* Arthur Brown, Jericho.
D 16 *Owl Brand Potato Fertilizer;* A. W. Clark, Marshfield.
E 1 *Plow Brand Fertilizer;* A. W. Clark, Marshfield.
K 14 *Twentieth Century Potato Manure with 2 Percent Potash;* M. A. Nelson, Montpelier.

CONCERNING THE TABLES ON PAGES 33 TO 42

These tables, from the point of view of the execution of the law, form the essential part of the bulletin. Therein are displayed side by side what the fertilizer manufacturer says he will furnish and what he does furnish, the one in *italics,* the other in **black face.** Furthermore all the details are given in order that the buyer may judge not only how much or how little plant food he gets for his money but how good or how inferior it is and what parts are good and what less good. While it is doubtless true that most buyers pay no attention to the work of the control, many who have done so have profited thereby in getting a larger return in plant food for a dollar spent as a result of their study of the matter. And in order that such as may wish to grasp the full purport of these tables may be enabled to do so, there has been published from time to time brief explanatory matter, and several years ago, a series of very full, almost painfully full, explanations of the meaning and significance of each piece of data was printed in bulletin 143.

In brief it may be said that the parallel **black face** and *italic* columns are the most serviceable means of comparing promises and actualities so far as the quantity of plant food is concerned; and that the other figures help one to determine more particularly the quality of a given fertilizer.

In this connection attention is called to the explanatory matter on pages 43 and 44 concerning the new and simplified form of tables dealing with the results of fertilizer inspection, as well as to the tables themselves on pages 45 to 49.

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
K 3	AA Potato Grower, 1916	1.16	0.98	0.39	1.05	**3.58**	*3.70*	2.50	5.07	1.83	**9.40**	*9.*	7.57	*8.*	**1.59**	*1.*
K 1	Special Grass and Garden Mixture, 1916.	2.80	4.00	0.99	1.12	**8.91**	*8.25*	3.16	2.30	1.02	**6.48**	*6.*	5.46	*5.*	**1.04**	*1.*
A 1	Ammoniated Fertilizer A	0.46	0.07	0.18	0.27	**0.98**	*0.82*	4.14	6.28	1.93	**12.35**	*11.*	10.42	*10.*	...	..
A 2	Ammoniated Fertilizer AA	0.75	0.58	0.07	0.32	**1.72**	*1.65*	5.60	5.16	1.21	**11.97**	*11.*	10.76	*10.*	...	..
A 3	Ammoniated Fertilizer AAA	1.05	0.77	0.20	0.65	**2.67**	*2.47*	5.42	4.58	1.84	**11.84**	*11.*	10.00	*10.*	...	..
A 4	Ammoniated Fertilizer AAAA	1.44	1.05	0.26	0.86	**3.61**	*3.29*	5.76	4.24	1.10	**11.10**	*11.*	10.00	*10.*	...	..
K 2	General Crop Grower, 1916	0.61	0.48	0.28	0.49	**1.86**	*1.65*	3.92	5.54	2.02	**11.48**	*10.*	9.46	*9.*	**0.97**	*1.*
A 5	Grass and Lawn Topdressing, 1916	1.57	1.27	0.33	0.90	**4.07**	*3.7*	2.96	5.24	1.36	**9.56**	*9.*	8.20	*8.*	**0.91**	*1.*
A 6	High Grade Fertilizer, 1916	1.05	0.77	0.29	0.63	**2.74**	*2.47*	4.62	4.40	1.32	**10.34**	*10.*	9.02	*9.*	**0.99**	*1.*
A 7	Topdresser, 1916	1.53	1.42	0.45	0.91	**4.31**	*4.1*	4.70	3.64	1.30	**9.64**	*9.*	8.34	*8.*	**0.88**	*1.*
	(*Bradley Fertilizer Co. Brands*)															
A 12	Circle Brand Bone and Potash, 1916	0.82	0.41	0.25	0.41	**1.89**	*1.65*	5.28	4.52	0.76	**10.56**	*10.*	9.80	*9.*	**1.00**	*1.*
A 8	Complete Manure for Corn & Grain, 1916	1.46	1.21	0.20	0.74	**3.61**	*3.29*	5.16	4.15	1.05	**10.36**	*10.*	9.31	*9.*	**0.92**	*1.*
A 9	Complete Manure for Pot. & Veg., 1916	1.37	1.12	0.17	0.88	**3.54**	*3.29*	4.20	4.97	1.15	**10.32**	*10.*	9.17	*9.*	**1.08**	*1.*
A 10	Complete Man. for Topdr. Grass & Grain	1.61	1.48	0.19	1.07	**4.35**	*4.1*	4.64	4.34	0.82	**9.80**	*9.*	8.98	*8.*	**1.00**	*1.*
A 11	Corn Phosphate, 1916	0.77	0.60	0.06	0.39	**1.82**	*1.65*	5.86	4.90	1.00	**11.76**	*11.*	10.76	*10.*	**0.96**	*1.*
A 13	Eclipse Phosphate, 1916	0.51	0.30	0.19	0.44	**1.44**	*1.23*	5.96	4.45	0.95	**11.36**	*11.*	10.41	*10.*	**1.00**	*1.*
A 14	High Grade Potato & Root Special, 1916.	0.61	0.51	0.15	0.34	**1.61**	*1.65*	6.04	4.74	0.82	**11.60**	*11.*	10.78	*10.*	**1.16**	*1.*
A 16	Potato Fertilizer, 1916	0.94	0.53	0.25	0.56	**2.28**	*2.06*	3.96	4.58	0.78	**9.32**	*9.*	8.54	*8.*	**1.01**	*1.*
A 15	Potato Manure, 1916	0.98	0.74	0.21	0.67	**2.60**	*2.47*	4.68	4.72	1.34	**10.74**	*10.*	9.40	*9.*	**1.01**	*1.*
B 1	XL Superphosphate of Lime, 1916	0.98	0.70	0.42	0.60	**2.70**	*2.47*	4.08	5.55	0.97	**10.60**	*10.*	9.63	*9.*	**1.04**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
	(Cleveland Dryer Co. Brands)															
B 4	General Crop Fertilizer, 1916	0.42	0.32	0.17	0.21	**1.12**	*0.82*	4.08	4.39	0.67	**9.14**	*9.*	**8.47**	*8.*	**0.84**	*1.*
B 3	Potato Phosphate, 1916	0.98	0.56	0.30	0.51	**2.35**	*2.06*	4.62	4.12	0.80	**9.54**	*9.*	**8.74**	*8.*	**0.95**	*1.*
B 2	Superphosphate, 1916	0.84	0.49	0.21	0.49	**2.03**	*1.65*	4.42	5.96	1.34	**11.72**	*11.*	**10.38**	*10.*	**0.89**	*1.*
	(Crocker Fertilizer & Chemical Co. Brands)															
G 11	Ammoniated Corn Phosphate, 1916.....	0.72	0.65	0.31	0.56	**2.24**	*2.06*	4.00	4.64	1.02	**9.66**	*9.*	**8.64**	*8.*	**1.12**	*1.*
B 6	New Rival Ammoniated Superphos., 1916	0.43	0.34	0.21	0.14	**1.12**	*0.82*	5.30	5.64	1.00	**11.94**	*11.*	**10.94**	*10.*	**0.94**	*1.*
B 5	Potato, Hop & Tobacco Fertilizer, 1916..	1.02	0.63	0.28	0.53	**2.46**	*2.06*	4.40	5.77	0.89	**11.06**	*11.*	**10.17**	*10.*	**1.09**	*1.*
G 12	Special Potato Fertilizer, 1916.....	1.34	1.05	0.27	0.88	**3.54**	*3.29*	3.72	5.96	1.16	**10.84**	*11.*	**9.68**	*10.*	**1.01**	*1.*
	(Darling Fertilizer Co. Brands)															
B 7	Farm Favorite, 1916	0.60	0.56	0.31	0.46	**1.93**	*1.65*	5.44	5.08	0.86	**11.38**	*11.*	**10.52**	*10.*	**0.93**	*1.*
B 8	General Fertilizer, 1916	0.35	0.32	0.17	0.25	**1.09**	*0.82*	3.90	4.90	0.92	**9.72**	*9.*	**8.80**	*8.*	**0.83**	*1.*
	(Great Eastern Fertilizer Co. Brands)															
B 9	General Fertilizer, 1916	0.35	0.35	0.28	0.28	**1.26**	*0.82*	4.68	4.47	0.93	**10.08**	*9.*	**9.15**	*8.*	**0.88**	*1.*
B 10	High Grade, Potato Fertilizer, 1916.....	1.14	0.93	0.54	0.86	**3.47**	*3.29*	4.68	4.74	1.02	**10.44**	*10.*	**9.42**	*9.*	**0.88**	*1.*
B 11	Northern Corn Special, 1916	0.73	0.67	0.46	0.46	**2.32**	*2.06*	3.84	4.92	1.14	**9.90**	*9.*	**8.76**	*8.*	**0.76**	*1.*
B 12	Potato Manure, 1916	0.74	0.63	0.43	0.55	**2.35**	*2.06*	5.58	4.42	1.33	**11.33**	*11.*	**10.00**	*10.*	**1.04**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
	(Pacific Guano Co. Brands)															
B 14	Nobsque Guano, 1916	0.31	0.25	0.24	0.25	**1.05**	*0.82*	4.44	4.01	1.07	**9.52**	*9.*	**8.45**	*8.*	**0.92**	*1.*
L 6	Potato Special, 1916	0.75	0.62	0.46	0.56	**2.39**	*2.06*	2.80	6.10	1.06	**9.96**	*9.*	**8.90**	*8.*	**0.86**	*1.*
B 13	Soluble Pacific Guano, 1916	0.70	0.56	0.31	0.39	**1.96**	*1.65*	5.82	4.56	1.28	**11.66**	*11.*	**10.38**	*10.*	**1.01**	*1.*
	(Quinnipiac Co. Brands)															
B 15	Corn Manure, 1916	0.63	0.56	0.28	0.39	**1.86**	*1.65*	4.68	5.88	1.44	**12.00**	*11.*	**10.56**	*10.*	**0.96**	*1.*
K 13	Market Garden Manure, 1916	0.97	1.42	0.49	0.84	**3.72**	*3.29*	4.76	4.82	0.82	**10.40**	*10.*	**9.58**	*9.*	**1.05**	*1.*
B 16	Potato Phosphate, 1916	0.70	0.63	0.44	0.58	**2.35**	*2.06*	4.62	3.84	1.16	**9.62**	*9.*	**8.46**	*8.*	**0.94**	*1.*
	(Read Fertilizer Co. Brands)															
J 4	Farmers' Friend Superphosphate, 1916..	0.77	0.60	0.42	0.60	**2.39**	*2.06*	4.16	4.20	1.06	**9.42**	*9.*	**8.36**	*8.*	**1.22**	*1.*
C 1	High Grade Farmers' Friend Super., 1916	1.35	1.18	0.31	0.67	**3.51**	*3.29*	4.84	4.98	1.22	**11.04**	*10.*	**9.82**	*9.*	**0.87**	*1.*
J 3	Practical Fertilizer, 1916	0.33	0.20	0.13	0.39	**1.05**	*0.82*	4.70	4.13	0.81	**9.64**	*9.*	**8.83**	*8.*	**0.83**	*1.*
	(Williams & Clark Fertilizer Co. Brands)															
C 3	Americus Corn Phosphate, 1916	0.65	0.44	0.13	0.46	**1.68**	*1.65*	4.44	6.42	0.58	**11.44**	*11.*	**10.86**	*10.*	**1.02**	*1.*
C 2	Americus H. G. Sp. for Pot. & Root Crops	1.33	1.02	0.26	0.76	**3.37**	*3.29*	4.68	4.82	0.72	**10.22**	*10.*	**9.50**	*9.*	**0.96**	*1.*
C 4	Americus Potato Manure, 1916	0.84	0.56	0.26	0.48	**2.14**	*2.06*	4.80	3.21	1.11	**9.12**	*9.*	**8.01**	*8.*	**0.91**	*1.*
K 15	Royal Bone Phosphate, 1916	0.52	0.46	0.53	0.35	**1.86**	*1.23*	7.22	3.21	1.59	**12.02**	*11.*	**10.43**	*10.*	**0.92**	*1.*
C 5	Special Prolific Crop Producer	0.35	0.28	0.17	0.32	**1.12**	*0.82*	4.88	3.29	0.94	**9.11**	*10.*	**8.17**	*9.*	**1.01**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Armour Fertilizer Works															
K 7	Five, Eight, One	...	0.86	0.33	3.16	4.35	*4.1*	5.36	2.33	1.41	9.10	*8.5*	7.69	*8.*	0.98	*1.*
C 9	Four, Eight, One	...	1.30	0.03	1.97	3.30	*3.29*	4.08	4.47	0.69	9.24	*8.5*	8.55	*8.*	0.98	*1.*
K 4	Four, Eight, Zero	...	1.09	0.49	1.65	3.23	*3.29*	6.26	2.05	0.57	8.88	*8.5*	8.31	*8.*	...	..
K 5	One and one-half, Nine, Zero	...	0.37	0.44	0.56	1.37	*1.23*	4.94	3.65	0.79	9.38	*9.5*	8.59	*9.*	...	..
C 8	Three, Eight, One	...	1.02	0.35	1.09	2.46	*2.47*	4.14	3.67	0.77	8.58	*8.5*	7.81	*8.*	0.92	*1.*
K 6	Two and one-half, Eight, Two	0.17	0.60	0.25	1.19	2.21	*2.05*	5.56	2.72	1.12	9.40	*8.5*	8.28	*8.*	2.02	*2.*
C 7	Two, Eight, One	...	0.20	0.23	1.18	1.61	*1.65*	3.52	3.82	0.82	8.16	*8.5*	7.34	*8.*	0.98	*1.*
C 6	Two, Eleven, Zero	...	0.46	0.17	1.02	1.65	*1.65*	7.80	3.84	0.78	12.42	*11.5*	11.64	*11.*	...	..
C 10	Wheat, Corn, Oats Special	...	0.23	0.05	0.67	0.95	*0.82*	5.14	1.97	0.59	7.70	*7.5*	7.11	*7.*	0.95	*1.*
	Bowker Fertilizer Co.															
H 15	All Round Fertilizer, 1916	0.56	0.46	0.27	0.46	1.75	*2.06*	5.28	6.45	1.27	13.00	*11.*	11.78	*11.*	0.82	*1.*
C 11	Brighton Phosphate	0.37	0.30	0.15	0.23	1.05	*0.82*	3.88	4.58	0.94	9.40	*9.*	8.46	*8.*	...	..
E 4	Corn Phosphate, 1916	0.37	0.86	0.29	0.55	2.07	*1.65*	4.68	5.88	1.14	11.70	*11.*	10.56	*10.*	0.94	*1.*
H 16	Farm and Garden Phosphate, 1916	0.59	0.46	0.25	0.56	1.86	*1.65*	5.04	5.91	1.05	12.00	*11.*	10.95	*11.*	0.81	*1.*
E 3	Hill and Drill Phosphate, 1916	0.78	0.90	0.23	0.76	2.67	*2.47*	4.00	5.38	1.22	10.60	*10.*	9.38	*9.*	0.92	*1.*
C 12	Potato Phosphate, 1916	0.65	0.51	0.17	0.39	1.72	*1.65*	5.12	4.98	1.18	11.28	*11.*	10.10	*10.*	0.99	*1.*
C 13	Stockbridge General Crop Manure, 1916.	1.21	1.11	0.33	0.86	3.51	*3.29*	4.58	4.74	1.28	10.60	*10.*	9.32	*9.*	0.90	*1.*
C 14	Stockbridge Cer. Man. without Pot'h, 1916	1.13	0.97	0.48	0.93	3.51	*3.29*	5.48	4.59	1.16	11.23	*11.*	10.07	*10.*	...	..
H 9	Stockbridge Early Crop Manure, 1916	1.60	1.35	0.45	0.98	4.38	*4.11*	3.62	4.79	1.33	9.74	*9.*	8.41	*8.*	0.89	*1.*

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Bowker Fertilizer Co.—Cont.															
C 15	Superphosphate with Ammo. 1%.....	0.35	0.28	0.14	0.21	**0.98**	*0.83*	6.48	4.52	0.78	**11.78**	*11.*	**11.00**	*10.*	...	..
C 16	Superphosphate with Ammo. 2%.....	0.59	0.60	0.28	0.32	**1.79**	*1.65*	6.00	4.36	1.00	**11.36**	*11.*	**10.36**	*10.*	...	..
E 2	Sure Crop Phosphate, 1916	...	0.30	0.29	0.39	**0.98**	*0.82*	5.58	4.82	1.00	**11.40**	*11.*	**10.40**	*10.*	**0.91**	*1.*
	Burlington Rendering Co.															
D 1	Animal Fertilizer	0.53	0.42	0.91	0.88	**2.74**	*2.46*	8.24	2.40	0.38	**11.02**	*11.*	**10.64**	*10.*	...	..
D 2	Grain Fertilizer	0.18	0.35	...	1.05	**1.58**	*1.23*	7.38	3.30	0.64	**11.32**	*11.*	**10.68**	*10.*	...	..
G 10	Grass Fertilizer	1.67	0.72	0.10	2.28	**4.77**	*4.92*	4.88	3.17	1.17	**9.22**	*9.*	**8.05**	*8.*	...	..
D 3	Potato Fertilizer	0.56	0.84	1.00	1.21	**3.61**	*3.28*	8.30	2.87	0.59	**11.76**	*11.*	**11.17**	*10.*	...	..
D 4	Special Fertilizer	0.49	0.49	0.18	1.58	**2.74**	*2.46*	6.84	4.43	0.33	**11.60**	*11.*	**11.27**	*10.*	**1.28**	*1.*
D 5	Vegetable Fertilizer	0.96	1.07	0.21	1.76	**4.00**	*4.1*	7.94	2.98	2.16	**13.08**	*11.*	**10.92**	*10.*	...	..
	The Coe-Mortimer Co.															
F 1	Columbian Corn & Potato Fertilizer, 1916	0.42	0.42	0.39	0.28	**1.51**	*1.23*	5.24	5.60	0.98	**11.82**	*11.*	**10.84**	*10.*	**1.02**	*1.*
E 5	Gold Brand Excelsior Guano, 1916.....	0.78	0.83	0.34	0.72	**2.67**	*2.47*	3.64	5.62	1.16	**10.42**	*10.*	**9.26**	*9.*	**0.98**	*1.*
F 3	High Grade Ammoniated Superphos., 1916	1.01	0.95	0.22	0.56	**2.74**	*2.47*	6.76	4.64	1.20	**12.60**	*11.*	**11.40**	*10.*	...	..
E 6	New Englander Special, 1916	0.32	0.21	0.13	0.32	**0.98**	*0.82*	4.72	3.87	0.75	**9.34**	*9.*	**8.59**	*8.*	**0.77**	*1.*
F 4	Red Brand Excelsior Guano, 1916	1.32	1.49	0.38	1.05	**4.24**	*4.11*	4.44	4.50	0.82	**9.76**	*9.*	**8.94**	*8.*	**1.05**	*1.*
F 2	Standard Potato Fertilizer, 1916.....	1.44	1.05	0.18	0.84	**3.51**	*3.29*	4.86	4.89	0.71	**10.46**	*10.*	**9.75**	*9.*	**1.04**	*1.*
J 15	Universal Fertilizer, 1916	0.68	0.55	0.31	0.49	**2.03**	*1.65*	4.96	4.54	1.32	**10.82**	*10.*	**9.50**	*9.*	...	..
F 5	XXX Ammoniated Phosphate, 1916.....	0.56	0.35	0.32	0.35	**1.58**	*0.82*	4.60	6.01	1.69	**12.30**	*11.*	**10.61**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Essex Fertilizer Co.															
E 7	Grain, Grass and Potato Fertilizer.....	...	...	0.44	0.44	**0.88**	*0.82*	6.48	5.64	0.60	**12.72**	*13.*	**12.12**	*12.*	...	..
H 7	Manure for Corn, Grain and Grass.....	0.51	0.72	1.02	1.05	**3.30**	*3.28*	7.22	2.82	0.88	**10.92**	*11.*	**10.04**	*10.*	**1.13**	*1.*
E 8	Market Garden and Potato Manure.....	0.45	0.67	0.57	1.14	**2.83**	*2.87*	6.86	3.02	0.76	**10.64**	*11.*	**9.88**	*10.*	...	..
F 6	Potato Grower	0.45	1.23	0.84	1.72	**4.24**	*4.1*	7.00	3.18	1.38	**11.56**	*11.*	**10.18**	*10.*	...	..
H 8	Special Potato, Grass and Lawn.....	0.40	1.84	0.99	1.75	**4.98**	*4.82*	6.42	1.67	1.13	**9.22**	*9.*	**8.09**	*8.*	...	..
E 9	XXX Fish Fertilizer	0.45	0.46	0.78	0.91	**2.60**	*2.46*	6.52	3.29	1.65	**11.46**	*11.*	**9.81**	*10.*	...	..
	International Agricultural Corporation, Buffalo Fertilizer Works															
D 6	Buffalo Ammoniated Phosphate.....	...	0.76	0.43	0.74	**1.93**	*1.2*	8.14	3.40	0.78	**12.32**	*13.*	**11.54**	*12.*	...	..
F 8	Buffalo Economy	...	0.53	0.42	0.77	**1.72**	*1.6*	6.92	4.53	0.65	**12.10**	*11.*	**11.45**	*10.*	**0.73**	*1.*
D 7	Buffalo Farmers' Choice	...	0.20	0.20	0.51	**0.91**	*0.8*	7.48	4.06	0.56	**12.10**	*11.*	**11.54**	*10.*	...	..
D 8	Buffalo General Favorite	...	0.46	0.29	0.58	**1.33**	*0.8*	5.78	2.82	0.76	**9.36**	*9.*	**8.60**	*8.*	**0.94**	*1.*
D 9	Buffalo High Grade Manure	1.40	0.63	0.39	0.95	**3.37**	*3.3*	6.16	3.26	1.00	**10.42**	*9.*	**9.42**	*8.*	**0.87**	*1.*
F 7	Buffalo New England Special	...	0.48	0.47	0.70	**1.65**	*1.6*	7.72	4.10	1.70	**13.52**	*11.*	**11.82**	*10.*	...	..
D 10	Buffalo Top Dresser	2.68	0.86	0.61	1.05	**5.20**	*5.8*	3.52	3.82	1.32	**8.66**	*7.*	**7.34**	*6.*	...	..
D 11	Buffalo Vegetable and Potato	...	0.90	0.57	1.16	**2.63**	*2.5*	7.76	3.24	1.14	**12.14**	*11.*	**11.00**	*10.*	...	..
	Listers' Agricultural Chemical Works															
K 8	Atlas Brand Fertilizer, 1916.....	1.12	1.62	0.95	1.05	**4.74**	*4.11*	4.48	3.31	2.72	**10.51**	*9.*	**7.79**	*8.*	...	..
F 16	Corn and Potato Fertilizer, 1916.....	...	1.23	0.56	0.53	**2.32**	*2.06*	2.66	4.70	2.23	**9.59**	*9.*	**7.36**	*8.*	**0.86**	*1.*
K 9	Crescent Ammo. Superphosphate, 1916...	...	0.56	0.38	0.88	**1.82**	*1.65*	5.62	3.91	2.75	**12.28**	*11.*	**9.53**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Listers' Agricultural Chemical Works—Cont.															
H 5	Excelsior Guano, 1916	...	0.97	0.61	1.30	**2.88**	*2.47*	6.20	4.47	2.69	**13.36**	*11.*	**10.67**	*10.*	...	..
G 16	High Gr. Special for Spring Crops, 1916..	...	0.90	0.60	0.53	**2.03**	*2.06*	6.64	3.94	1.22	**11.80**	*11.*	**10.58**	*10.*	**0.82**	*1.*
H 3	High Grade Topdresser, 1916	3.33	3.79	0.46	0.84	**8.42**	*8.23*	3.92	2.10	0.98	**7.00**	*6.*	**6.02**	*5.*	**0.74**	*1.*
H 4	Plant Food, 1916	...	0.14	0.35	0.60	**1.09**	*0.82*	7.56	4.02	1.20	**12.78**	*11.*	**11.58**	*10.*	...	..
G 15	Potato Manure, 1916	1.05	1.69	0.52	0.60	**3.86**	*4.11*	4.18	4.71	1.87	**10.76**	*9.*	**8.89**	*8.*	**0.77**	*1.*
G 13	Revised Vt. Corn & Potato Fert., 1916....	...	0.35	0.14	0.49	**0.98**	*0.82*	4.72	4.30	1.02	**10.04**	*9.*	**9.02**	*8.*	**0.92**	*1.*
K 16	Special Potato Fertilizer, 1916	1.01	1.48	0.81	1.05	**4.35**	*4.11*	1.44	9.12	2.64	**13.20**	*11.*	**10.56**	*10.*	...	..
H 1	Standard Grass Fertilizer, 1916	0.66	1.44	0.28	0.25	**2.63**	*2.47*	6.52	3.21	0.71	**10.44**	*10.*	**9.73**	*9.*	**0.86**	*1.*
G 14	Success Fertilizer, 1916	...	0.44	0.22	0.60	**1.26**	*1.23*	7.60	4.47	1.03	**13.10**	*11.*	**12.07**	*10.*	**0.89**	*1.*
H 2	Superior Ammo. Superphos., 1916	0.92	0.97	0.57	1.05	**3.51**	*3.29*	4.24	5.74	2.74	**12.72**	*11.*	**9.98**	*10.*	...	..
	Lowell Fertilizer Co.															
F 9	Animal Brand for All Crops	0.52	0.67	0.57	1.19	**2.95**	*2.89*	6.84	3.54	0.86	**11.24**	*11.*	**10.38**	*10.*	...	..
F 10	Bone Fert. for Corn, Grain, Grass & Veg.	0.17	0.32	0.68	0.88	**2.05**	*2.05*	6.32	3.70	1.38	**11.40**	*11.*	**10.02**	*10.*	...	..
F 11	Corn and Vegetable Manure	0.49	1.09	0.88	1.54	**4.00**	*4.1*	7.16	2.50	1.70	**11.36**	*11.*	**9.66**	*10.*	...	..
F 12	Empress Brand for Corn, Pot. & Grain...	...	...	0.67	0.56	**1.23**	*1.25*	6.92	2.73	1.34	**10.99**	*11.*	**9.65**	*10.*	...	..
H 6	Market Garden, Special Grass & Lawn..	0.40	2.09	0.88	1.61	**4.98**	*4.82*	4.86	3.59	0.95	**9.40**	*9.*	**8.45**	*8.*	...	..
F 13	Potato Manure	0.53	0.42	0.70	0.91	**2.56**	*2.46*	7.04	2.98	1.71	**11.73**	*11.*	**10.02**	*10.*	...	..
F 14	Potato Phosphate	0.45	0.88	0.98	1.09	**3.40**	*3.28*	7.62	2.54	0.88	**11.04**	*11.*	**10.16**	*10.*	...	..
F 15	Sterling Phosphate	...	...	0.56	0.35	**0.91**	*0.82*	10.12	2.57	1.63	**14.32**	*13.*	**12.69**	*12.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	National Fertilizer Co.															
E 10	Eureka Potato Fertilizer, 1916	0.86	0.86	0.42	0.60	2.74	*2.47*	4.98	4.64	1.00	10.62	*10.*	9.62	*9.*	0.96	*1.*
J 16	Potato Phosphate, 1916	0.88	0.56	0.35	0.49	2.28	*2.06*	4.08	4.72	1.06	9.86	*9.*	8.80	*8.*	1.02	*1.*
E 11	Special Complete Fertilizer, 1916	1.25	1.07	0.36	0.69	3.37	*3.29*	4.26	5.06	1.06	10.38	*10.*	9.32	*9.*	0.97	*1.*
E 12	Universal Fertilizer, 1916	0.36	0.34	0.23	0.23	1.16	*0.82*	4.58	4.52	0.90	10.00	*9.*	9.10	*8.*	1.12	*1.*
	New England Fertilizer Co.															
K 11	Complete Manure, Potatoes & Vegetables	0.40	0.83	1.12	1.09	3.44	*3.28*	7.64	2.57	1.19	11.40	*11.*	10.21	*10.*	1.22	*1.*
K 12	Corn and Grain Fertilizer	...	...	0.74	0.63	1.37	*1.23*	7.00	2.85	1.65	11.50	*11.*	9.85	*10.*	...	..
K 10	Corn Phosphate	...	0.39	0.84	0.98	2.21	*2.05*	6.56	3.26	1.75	11.57	*11.*	9.82	*10.*	...	..
H 12	Potato Fertilizer	0.47	0.44	0.74	0.88	2.53	*2.46*	4.08	6.24	0.94	11.26	*11.*	10.32	*10.*	...	..
H 10	Potato and Vegetable	...	2.02	1.14	1.05	4.21	*4.1*	7.22	2.61	1.13	10.96	*11.*	9.83	*10.*	...	..
H 11	Superphosphate for All Crops	0.50	0.69	0.92	1.05	3.16	*2.87*	6.54	4.17	0.87	11.58	*11.*	10.71	*10.*	...	..
	Parmenter & Polsey Fertilizer Co.															
D 12	Corn and Grain Fertilizer	...	...	0.44	0.44	0.88	*0.82*	6.64	5.68	0.40	12.72	*12.*	12.32	*12.*	...	..
L 5	Grain Grower	0.23	0.30	0.84	0.95	2.32	*1.23*	6.58	3.50	1.16	11.24	*11.*	10.08	*10.*	...	..
D 13	Plymouth Rock Brand Fertilizer	0.49	0.67	0.63	1.16	2.95	*2.88*	7.44	3.05	0.83	11.32	*11.*	10.49	*10.*	1.01	*1.*
L 3	Potato and Vegetable	0.35	1.97	0.95	1.68	4.95	*4.97*	6.06	2.09	1.21	9.36	*9.*	8.15	*8.*	...	..
D 14	Potato Fertilizer	...	0.35	0.87	0.88	2.10	*2.05*	7.10	3.60	1.32	12.02	*11.*	10.70	*10.*	...	..
L 1	Potato Phosphate	0.47	0.90	1.09	1.05	3.51	*3.28*	7.24	2.89	1.01	11.14	*11.*	10.13	*10.*	...	..
L 4	Special Potato	0.40	1.21	0.99	1.68	4.28	*4.1*	7.12	2.94	1.88	11.94	*11.*	10.06	*10.*	...	..
L 2	Star Brand Superphosphate	0.46	0.42	0.70	0.88	2.46	*2.46*	6.56	3.37	1.63	11.56	*11.*	9.96	*10.*	...	..

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Reading Bone Fertilizer Co.															
E	13 All Crop Special	....	0.70	0.63	0.60	**1.93**	*1.64*	5.02	4.32	2.68	**12.02**	*11.*	**9.34**	*10.*	...	..
E	16 Farmers' Tankage & Potash for Corn, etc.	...	0.14	0.09	0.65	**0.88**	*0.82*	0.64	9.14	2.74	**12.52**	*11.*	**9.78**	*10.*	**0.87**	*1.*
H	14 Never Fail Crop Grower	...	0.13	0.46	0.53	**1.12**	*0.82*	4.20	6.73	1.41	**12.34**	*11.*	**10.93**	*10.*	...	..
H	13 Prize Winner	...	1.37	0.49	0.49	**2.35**	*2.46*	5.06	3.53	1.46	**10.05**	*10.*	**8.59**	*9.*	...	..
E	14 Special Grain and Grass Producer	...	0.09	0.17	0.72	**0.98**	*0.82*	3.70	3.59	2.17	**9.46**	*8.*	**7.29**	*7.*	...	..
E	15 Potato and Tobacco Manure	...	0.27	0.36	0.42	**1.05**	*0.82*	6.68	5.71	1.79	**14.18**	*13.*	**12.39**	*12.*	...	..
L	7 Truck, Fruit, Tree, Vine, Potato, etc.	...	1.83	0.84	0.70	**3.37**	*3.28*	4.12	3.72	2.31	**10.15**	*9.*	**7.84**	*8.*	...	..
	Rogers & Hubbard Co.															
G	1 All Soils—All Crops Phosphate	2.14	0.07	0.81	0.70	**3.72**	*3.3*	2.56	4.18	2.42	**9.16**	*9.*	**6.74**	*7.*	...	..
G	2 Complete Phosphate	...	...	0.63	0.56	**1.19**	*1.*	4.92	4.32	2.40	**11.64**	*11.*	**9.24**	*9.*	...	..
G	3 Fertilizer for Oats and Topdressing	4.75	0.16	0.42	0.74	**6.07**	*6.*	0.16	8.14	6.62	**14.92**	*12.*	**8.30**	*6.*	...	..
G	4 Potato Phosphate	0.73	0.11	0.77	0.56	**2.17**	*2.*	4.60	8.04	3.16	**15.80**	*15.*	**12.64**	*13.*	...	..
G	5 Soluble Corn and General Crops Manure	1.47	0.14	0.50	0.63	**2.74**	*2.5*	2.68	6.22	5.32	**14.22**	*12.*	**8.90**	*10.*	...	..
J	5 Soluble Potato Manure	2.01	0.27	0.63	1.51	**4.42**	*4.25*	0.44	9.94	6.50	**16.88**	*16.*	**10.38**	*10.*	**1.00**	*1.*
	F. S. Royster Guano Co.															
J	6 Cuckoo Crop Grower	...	0.48	0.05	0.42	**0.95**	*0.82*	4.16	4.12	0.76	**9.04**	*8.5*	**8.28**	*8.*	...	..
J	7 Curfew Ammoniated Superphosphate	...	1.76	0.31	1.51	**3.58**	*3.29*	6.04	2.55	0.89	**9.48**	*8.5*	**8.59**	*8.*	...	..
J	8 Defender Fertilizer	...	1.12	0.53	1.58	**3.23**	*3.29*	3.62	4.08	2.14	**9.84**	*8.5*	**7.70**	*8.*	**0.94**	*1.*
J	9 Drillwell Phosphate	...	0.79	0.58	1.23	**2.60**	*2.47*	3.44	4.13	1.77	**9.34**	*8.5*	**7.57**	*8.*	**1.06**	*1.*

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	F. S. Royster Guano Co.—Cont.															
J 14	Goodwill Ammoniated Superphosphate..	...	2.00	0.18	1.68	**3.86**	*4.11*	5.98	2.95	1.23	**10.16**	*8.5*	**8.98**	*8.*	...	..
J 13	Innovation Ammoniated Superphosphate.	...	1.46	0.05	1.05	**2.56**	*2.47*	6.86	2.56	0.82	**10.24**	*8.5*	**9.42**	*8.*	...	..
J 10	Log Cabin Guano	...	1.76	0.66	1.72	**4.14**	*4.11*	3.32	4.47	2.41	**10.20**	*8.5*	**7.79**	*8.*	**0.99**	*1.*
J 11	Logical Compound	...	0.41	0.50	0.77	**1.68**	*1.65*	3.20	5.04	0.92	**9.16**	*8.5*	**8.24**	*8.*	**0.95**	*1.*
J 12	Penguin Ammoniated Superphosphate...	...	0.72	0.54	0.60	**1.86**	*1.65*	6.88	5.06	1.92	**13.86**	*10.5*	**11.94**	*10.*	...	..
	J. W. Sanborn															
L 8	Prof. Sanborn's for Grass and Grain.....	1.89	0.28	1.20	1.30	**4.67**	*4.94*	0.36	6.78	3.52	**10.66**	*9.*	**7.14**	*8.*	...	..
J 2	Prof. Sanborn's for Hill and Drill.....	...	0.20	0.68	1.61	**2.49**	*2.47*	2.64	5.06	3.48	**11.18**	*9.*	**7.70**	*8.*	...	..
J 1	Prof. Sanborn's for Potatoes and Corn...	...	0.20	0.78	2.32	**3.30**	*3.29*	2.86	4.34	3.00	**10.20**	*9.*	**7.20**	*8.*	...	..
	Sanderson Fertilizer & Chemical Co.															
G 6	Atlantic Coast Bone, Fish & Potash, 1916	...	0.07	0.56	1.05	**1.68**	*1.64*	1.12	9.04	1.64	**11.80**	*10.*	**10.16**	*9.*	**1.05**	*1.*
G 7	Corn Superphosphate, 1916.....	...	0.07	0.81	1.05	**1.93**	*1.64*	2.38	8.84	1.24	**12.46**	*11.*	**11.22**	*10.*	**1.25**	*1.*
G 8	Potato Manure, 1916	...	0.16	0.86	1.44	**2.46**	*2.06*	3.00	6.59	2.29	**11.88**	*9.*	**9.59**	*8.*	**1.12**	*1.*
	Virginia-Carolina Chemical Co.															
D 15	Ammoniated Bone Phos. for All Crops...	...	0.23	0.36	1.27	**1.86**	*1.65*	4.52	5.26	2.28	**12.06**	*11.*	**9.78**	*10.*	...	..
G 9	High Grade Corn and Vegetable Comp...	0.80	0.11	0.39	1.47	**2.77**	*2.47*	4.34	4.22	1.62	**10.18**	*9.*	**8.56**	*8.*	***1.24**	*1.*
D 16	Owl Brand Potato Fertilizer.....	...	0.34	0.67	0.81	**1.82**	*1.65*	6.08	2.54	1.94	**10.56**	*9.*	**8.62**	*8.*	***0.94**	*1.*
E 1	Plow Brand Fertilizer	...	0.35	0.17	0.46	**0.98**	*0.82*	6.54	1.64	1.18	**9.36**	*9.*	**8.18**	*8.*	***1.18**	*1.*
K 14	20th Century Pot. Man. with 2% Potash.	1.45	0.23	0.99	1.75	**4.42**	*4.12*	2.08	6.41	1.83	**10.32**	*9.*	**8.49**	*8.*	***2.43**	*2.*

*Potash as sulphate.

CONCERNING THE TABLES ON PAGES 45 TO 49

There have been those who have found that the tables of analyses printed in the annual bulletin were somewhat complicated and difficult to understand, that comparisons were not readily made, and they have pled for simpler, more direct statements. The writers have felt that full statements as to the analytical data were really needed—and they still feel so. They have felt that the ideas could be readily grasped if one set himself seriously to study the matter. However, recognizing that publicity is the most effective weapon in their hands in the enforcement of the law and that anything which will tend to clarify the situation in the buyer's mind is worth while, they have formulated an additional and simpler statement as to the results of inspection. This is set forth on pages 45 to 49. This form is used tentatively this year. In the theatrical parlance it is "tried on the dog." The writers are not at all sure that it will be in any respect a help. It may be a hindrance. That this particular form will be followed in future years they cannot guarantee. It simply represents their sincere attempt to reduce the analytical statements to their simplest terms.

In order to set forth the meaning of these new tables a few words of explanation seem necessary.

The law requires a manufacturer to state on each package how much plant food he is selling. Long years of experience have indicated clearly that manufacturers rarely give more than they promise; on the average of late years it is not more than seven percent. Such being the case, the buyer is interested primarily in knowing whether or not the promise which has been made has been kept.

The first three figures in the table, reading horizontally following the brand name, indicate what the promise is; and the word following, usually "Yes," rarely "No," tells in this laconic, straightforward fashion whether or not the promise has been kept.

The remaining words and figures, other than the last figure in the horizontal line, have to do with *the quality of the nitrogen* which is furnished. This is an important item of information. In the first place *by the use of the words "Passed" or "Inferior" the character of the organic nitrogen used is indicated.* The former word is used whenever the analysis indicated a good or passable grade; the latter when it did not. The next three horizontal statements in terms of figures indicate *the proportions of the total nitrogen present in the several forms;* of nitrate nitrogen—derived from nitrate of soda; of ammonia—derived usually from sulphate of ammonia; and of organic

nitrogen—derived usually from materials like tankage, dried blood, dried fish, and other residues of a nitrogenous character. These figures are expressed in terms of tenths, and the three added always equal unity. Thus if, for example, a set of figures reads horizontally .4 .3 .3, it means that the nitrogen was furnished in those proportions in the form of nitrate, in the form of ammonia salts and in the form of organic nitrogen; 4 parts in 10 as nitrate, 3 parts in 10 as ammonia salts, and 3 parts in 10 as organic matter. If, as is often the case, no figure whatever appears, it should be understood that no nitrogen in the form indicated by the blank was used in the goods. This seems a simple, straightforward statement. It does not indicate whether the promise was high or low; that is betrayed by the manufacturer's guaranty, the first figures in the horizontal column. It simply shows what sort of material the manufacturer has used to furnish the nitrogen.

The last figure, reading horizontally, indicates in terms of a decimal fraction, *what part of the total phosphoric acid is furnished in available form.*

So far as potash is concerned the manufacturer's guaranty column serves the purpose for this year.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	American Agricultural Chemical Co.									
K 3	AA Potato Grower, 1916	3.7	8	1	Yes	Passed	.5	..	.5	.8
A 1	Ammoniated Fertilizer A	0.8	10	..	"	"	.4	.3	.3	.9
A 2	Ammoniated Fertilizer AA	1.7	10	..	"	"	.4	.3	.3	.8
A 3	Ammoniated Fertilizer AAA	2.5	10	..	"	"	.4	.3	.3	.9
A 4	Ammoniated Fertilizer AAAA	3.3	10	..	"	"	.3	.3	.4	.8
K 2	General Crop Grower, 1916	1.7	9	1	"	"	.4	.3	.3	.8
A 5	Gr. and Lawn Topdressing, 1916	3.7	8	1	"	"	.4	.3	.3	.9
A 6	High Grade Fertilizer, 1916	2.5	8	1	"	"	.3	.3	.4	.8
K 1	Spec. Gr. & Gard. Mixture, 1916	8.3	5	1	"	"	.3	.5	.2	.8
A 7	Topdresser, 1916	4.1	8	1	"	"	.4	.3	.3	.9
	(Bradley Fertilizer Co. Brands)									
A 12	Circle Br. Bone and Pot., 1916	1.7	9	1	Yes	Passed	.4	.2	.4	.9
A 8	Com. Man. for Corn & Gr., 1916	3.3	9	1	"	"	.4	.3	.3	.9
A 9	Com. Man. for Pot. & Veg., 1916	3.3	9	1	"	"	.4	.3	.3	.9
A 10	Com. Man. for Topdr. Gr. & Gr.	4.1	8	1	"	"	.4	.3	.3	.9
A 11	Corn Phosphate, 1916	1.7	10	1	"	"	.4	.3	.3	.9
A 13	Eclipse Phosphate, 1916	1.2	10	1	"	"	.4	.2	.4	.9
A 14	High Gr. Pot. & Root Spec., 1916	1.7	10	1	"	"	.4	.3	.3	.9
A 16	Potato Fertilizer, 1916	2.1	8	1	"	"	.4	.2	.4	.9
A 15	Potato Manure, 1916	2.5	9	1	"	"	.4	.3	.3	.9
B 1	XL Superphos. of Lime, 1916	2.5	9	1	"	"	.4	.3	.3	.9
	(Cleveland Dryer Co. Brands)									
B 4	General Crop Fertilizer, 1916	.8	8	.1	Yes	Passed	.4	.3	.3	.9
B 3	Potato Phosphate, 1916	2.1	8	1	"	"	.4	.2	.4	.9
B 2	Superphosphate, 1916	1.7	10	1	"	"	.4	.2	.4	.9
	(Crocker Fertilizer & Chemical Co. Brands)									
G 11	Ammo'd Corn Phosphate, 1916	2.1	8	1	Yes	Passed	.3	.3	.4	.9
B 6	New Rival Ammo'd Super., 1916	.8	10	1	"	"	.4	.3	.3	.9
B 5	Pot., Hop & Tob. Fertilizer, 1916	2.1	10	1	"	"	.4	.3	.3	.9
G 12	Spec. Potato Fertilizer, 1916	3.3	10	1	"	"	.4	.3	.3	.9
	(Darling Fertilizer Co. Brands)									
B 7	Farm Favorite, 1916	1.7	10	1	Yes	Passed	.3	.3	.4	.9
B 8	General Fertilizer, 1916	.8	8	1	"	"	.3	.3	.4	.9
	(Great Eastern Fertilizer Co. Brands)									
B 9	General Fertilizer, 1916	.8	8	1	Yes	Passed	.3	.3	.4	.9
B 10	High Gr. Potato Fertilizer, 1916	3.3	9	1	"	"	.3	.3	.4	.9
B 11	Northern Corn Special, 1916	2.1	8	1	"	"	.3	.3	.4	.9
B 12	Potato Manure, 1916	2.1	10	1	"	"	.3	.3	.4	.9
	(Pacific Guano Co. Brands)									
B 14	Nobeque Guano, 1916	.8	8	1	Yes	Passed	.3	.2	.5	.9
L 6	Potato Special, 1916	2.1	8	1	"	"	.3	.3	.4	.9
B 13	Soluble Pacific Guano, 1916	1.7	10	1	"	"	.4	.3	.3	.9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	American Agricultural Chemical Co.—Continued									
	(Quinnipiac Co. Brands)									
B 15	Corn Manure, 1916	1.7	10	1	Yes	Passed	.3	.3	.4	.9
K 13	Market Garden Manure, 1916	3.3	9	1	"	"	.3	.4	.3	.9
B 16	Potato Phosphate, 1916	2.1	8	1	"	"	.3	.3	.4	.9
	(Read Fertilizer Co. Brands)									
J 4	Farmers' Fr. Superphos., 1916	2.1	8	1	Yes	Passed	.3	.3	.4	.9
C 1	H. G. Farmers' Fr. Super. 1916	3.3	9	1	"	"	.4	.3	.3	.9
J 3	Practical Fertilizer, 1916	.8	8	1	"	"	.3	.2	.5	.9
	(Williams & Clark Fertilizer Co. Brands)									
C 3	Americus Corn Phosphate, 1916	1.7	10	1	Yes	Passed	.4	.3	.3	.9
C 2	Americus H. G. Spec. for Pot. & Root Crops, 1916	3.3	9	1	"	"	.4	.3	.3	.9
C 4	Americus Potato Manure, 1916	2.1	8	1	"	"	.4	.3	.3	.9
K 15	Royal Bone Phosphate, 1916	1.2	10	1	"	"	.3	.2	.5	.9
C 5	Special Prolific Crop Producer	.8	9	1	No	"	.3	.3	.4	.9
	Armour Fertilizer Works									
K 7	Five, Eight, One	4.1	8	1	Yes	Passed	..	.2	.8	.8
C 9	Four, Eight, One	3.3	8	1	"	"	..	.4	.6	.9
K 4	Four, Eight, Zero	3.3	8	0	"	"	..	.3	.7	.9
K 5	One and one-half, Nine, Zero	1.2	9	0	"	"	..	.3.	.7	.9
C 8	Three, Eight, One	2.5	8	1	"	"	..	.4	.6	.9
K 6	Two and one-half, Eight, Two	2.1	8	2	"	"	.1	.3	.6	.9
C 7	Two, Eight, One	1.7	8	1	No	"	..	.1	.9	.9
C 6	Two, Eleven, Zero	1.7	11	0	Yes	"	..	.3	.7	.9
C 10	Wheat, Corn, Oats Special	.8	7	1	"	"	..	.2	.8	.9
	Bowker Fertilizer Co.									
H 15	All Round Fertilizer, 1916	2.1	11	1	Yes	Passed	.3	.3	.4	.9
C 11	Brighton Phosphate	.8	8	0	"	"	.4	.3	.3	.9
E 4	Corn Phosphate, 1916	1.7	10	1	"	"	.2	.4	.4	.9
H 16	Farm and Garden Phos., 1916	1.7	11	1	"	"	.3	.2	.5	.9
E 3	Hill and Drill Phosphate, 1916	2.5	9	1	"	"	.3	.3	.4	.9
C 12	Potato Phosphate, 1916	1.7	10	1	"	"	.4	.3	.3	.9
C 13	Stockbridge Gen. Cr. Man., 1916	3.3	9	1	"	"	.3	.3	.4	.9
C 14	Stockbridge Cereal Manure without Potash, 1916	3.3	10	0	"	"	.3	.3	.4	.9
H 9	Stockbridge Early Crop Man., 1916	4.1	8	1	"	"	.4	.3	.3	.9
C 15	Superphos. with Ammo. 1%	.8	10	0	"	"	.4	.3	.3	.9
C 16	Superphos. with Ammo. 2%	1.7	10	0	"	"	.3	.3	.4	.9
E 2	Sure Crop Phosphate, 1916	.8	10	1	"	"	..	.3	.7	.9

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CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Burlington Rendering Co.									
D 1	Animal Fertilizer	2.5	10	0	Yes	Passed	.2	.3	.5	1.0
D 2	Grain Fertilizer	1.2	10	0	"	"	.1	.2	.7	.9
G 10	Grass Fertilizer	4.9	8	0	"	"	.4	.2	.4	.9
D 3	Potato Fertilizer	3.3	10	0	"	"	.2	.3	.5	1.0
D 4	Special Fertilizer	2.5	10	1	"	"	.3	.3	.4	1.0
D 5	Vegetable Fertilizer	4.1	10	0	"	"	.2	.3	.5	.8
	The Coe-Mortimer Co.									
F 1	Columbian Corn & Pot., 1916	1.2	10	1	Yes	Passed	.3	.3	.4	.9
E 5	Gold Br. Excelsior Guano, 1916	2.5	9	1	"	"	.3	.3	.4	.9
F 3	H. G. Ammo. Superphos., 1916.	2.5	10	0	"	"	.4	.3	.3	.9
E 6	New Englander Special, 1916..	.8	8	1	"	"	.3	.2	.5	.9
F 4	Red Br. Excelsior Guano, 1916.	4.1	8	1	"	"	.3	.4	.3	.9
F 2	Standard Potato Fert., 1916....	3.3	9	1	"	"	.4	.3	.3	.9
J 15	Universal Fertilizer, 1916.....	1.7	9	0	"	"	.3	.3	.4	.9
F 5	XXX Ammo. Phosphate., 1916..	.8	10	0	"	"	.4	.2	.4	.9
	Essex Fertilizer Co.									
E 7	Grain, Grass & Potato Fert.....	.8	12	0	Yes	Passed	..	..	1.0	1.0
H 7	Man. for Corn, Grain & Grass.	3.3	10	1	"	"	.2	.2	.6	.9
E 8	Market Garden & Potato Man..	2.9	10	0	"	"	.2	.3	.5	.9
F 6	Potato Grower	4.1	10	0	"	"	.1	.3	.6	.9
H 8	Special Potato, Grass & Lawn.	4.8	8	0	"	"	.1	.4	.5	.9
E 9	XXX Fish Fertilizer	2.5	10	0	"	"	.2	.2	.6	.9
	International Agricultural Corporation, Buffalo Fertilizer Works									
D 6	Buffalo Ammoniated Phosphate	1.2	12	0	Yes	Passed	..	.4	.6	.9
F 8	Buffalo Economy	1.6	10	1	"	"	..	.3	.7	.9
D 7	Buffalo Farmers' Choice	.8	10	0	"	"	..	.2	.8	1.0
D 8	Buffalo General Favorite	.8	8	1	"	"	..	.3	.7	.9
D 9	Buffalo High Grade Manure	3.3	8	1	"	"	.4	.2	.4	.9
F 7	Buffalo New England Special..	1.6	10	0	"	"	..	.3	.7	.9
D 10	Buffalo Top Dresser	5.8	6	0	"	"	.5	.2	.3	.8
D 11	Buffalo Vegetable and Potato..	2.5	10	0	"	"	..	.3	.7	.9
	Listers' Agricultural Chemical Works									
K 8	Atlas Brand Fertilizer, 1916	4.1	8	0	Yes	Passed	.2	.3	.5	.7
F 16	Corn and Potato Fertilizer, 1916	2.1	8	1	No	"	..	.5	.5	.8
K 9	Crescent Ammo. Super., 1916.	1.7	10	0	"	"	..	.3	.7	.8
H 5	Excelsior Guano, 1916	2.5	10	0	Yes	"	..	.3	.7	.8
G 16	H. G. Spec. for Spr. Crops, 1916	2.1	10	1	"	"	..	.4	.6	.9
H 3	High Grade Topdresser, 1916..	8.2	5	1	"	"	.4	.4	.2	.9
H 4	Plant Food, 1916	.8	10	0	"	Inferior	..	.1	.9	.9
G 15	Potato Manure, 1916	4.1	8	1	"	Passed	.3	.4	.3	.8
G 13	*Revised* Vt. Corn & Potato, 1916	.8	8	1	"	"	..	.4	.6	.9
K 16	Special Potato Fertilizer, 1916.	4.1	10	0	"	"	.2	.3	.5	.8

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CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Listers' Agricultural Chemical Works—Continued									
H 1	Standard Grass Fertilizer, 1916	2.5	9	1	Yes	Passed	.2	.6	.2	.9
G 14	Success Fertilizer, 1916	1.2	10	1	"	"	..	.4	.6	.9
H 2	Super. Ammo. Superphos., 1916	3.3	10	0	"	"	.3	.3	.4	.8
	Lowell Fertilizer Co.									
F 9	Animal Brand for All Crops	2.9	10	0	Yes	Passed	.2	.2	.6	.9
F 10	Bone Fertilizer for Corn, Grain, Grass and Vegetables	2.1	10	0	"	"	.1	.2	.7	.9
F 11	Corn and Vegetable Manure	4.1	10	0	No	"	.1	.3	.6	.9
F 12	Empress Brand for Corn, Potatoes and Grain	1.3	10	0	No	"	..	..	1.0	.9
H 6	Mkt. Gard., Spec. Grass, Lawn	4.8	8	0	Yes	"	.1	.4	.5	.9
F 13	Potato Manure	2.5	10	0	"	"	.2	.2	.6	.8
F 14	Potato Phosphate	3.3	10	0	"	"	.1	.3	.6	.9
F 15	Sterling Phosphate	.8	12	0	"	"	..	..	1.0	.9
	National Fertilizer Co.									
E 10	Eureka Potato Fertilizer, 1916	2.5	9	1	Yes	Passed	.3	.3	.4	.9
J 16	Potato Phosphate, 1916	2.1	8	1	"	"	.4	.2	.4	.9
E 11	Special Complete Fert., 1916	3.3	9	1	"	"	.4	.3	.3	.9
E 12	Universal Fertilizer, 1916	.8	8	1	"	"	.3	.3	.4	.9
	New England Fertilizer Co.									
K 11	Complete Manure, Potato & Veg.	3.3	10	1	Yes	Passed	.1	.2	.7	.9
K 12	Corn and Grain Fertilizer	1.2	10	0	"	"	..	..	1.0	.9
K 10	Corn Phosphate	2.1	10	0	"	"	..	.2	.8	.8
H 12	Potato Fertilizer	2.5	10	0	"	"	.2	.2	.6	.9
H 10	Potato and Vegetable	4.1	10	0	"	"	..	.5	.5	.9
H 11	Superphosphate for All Crops	2.9	10	0	"	"	.2	.3	.5	.9
	Parmenter & Polsey Fertilizer Co.									
D 12	Corn and Grain Fertilizer	.8	12	0	Yes	Passed	..	..	1.0	1.0
L 5	Grain Grower	1.2	10	0	"	"	.1	.1	.8	.9
D 13	Plymouth Rock Brand Fertilizer	2.9	10	1	"	"	2.	.2	.6	.9
L 3	Potato and Vegetable	5.	8	0	"	"	.1	.4	.5	.9
D 14	Potato Fertilizer	2.1	10	0	"	"	..	.2	.8	.9
L 1	Potato Phosphate	3.3	10	0	"	"	.1	.3	.6	.9
L 4	Special Potato	4.1	10	0	"	"	.1	.3	.6	.8
L 2	Star Brand Superphosphate	2.5	10	0	"	"	.2	.2	.6	.9
	Reading Bone Fertilizer Co.									
H 13	Prize Winner	2.5	9	0	No	Passed	..	.6	.4	.9
E 16	Farmers' Tankage and Potash for Corn, Grain and Grass	.8	10	1	Yes	"	..	.2	.8	.8
H 14	Never Fail Crop Grower	.8	10	0	"	"	..	.1	.9	.9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Reading Bone Fertilizer Co.—Continued									
H 13	Prize Winner	2.5	9	0	No	Passed	..	.6	.4	.9
E 14	Special Grain & Grass Producer	.8	7	0	Yes	"	..	.1	.9	.8
E 15	Potato and Tobacco Manure	.8	12	0	"	"	..	.3	.7	.9
L 7	Truck, Fruit, Tree, Vine, Potato & Tobacco Grower	3.3	8	0	"	"	..	.5	.5	.8
	Rogers & Hubbard Co.									
G 1	All Soils—All Crops Phosphate.	3.3	7	0	Yes	Passed	.6	..	.4	.7
G 2	Complete Phosphate	1.	9	0	"	"	..	..	1.0	.8
G 3	Fertilizer for Oats & Topdress.	6.	6	0	"	"	.8	..	.2	.6
G 4	Potato Phosphate	2.	13	0	"	"	.3	..	.7	.8
G 5	Soluble Corn & Gen. Crops Man.	2.5	10	0	No	"	.5	..	.5	.6
J 5	Soluble Potato Manure	4.3	10	1	Yes	"	.5	.7	.4	.6
	F. S. Royster Guano Co.									
J 6	Cuckoo Crop Grower	.8	8	0	Yes	Inferior	..	.5	.5	.9
J 7	Curfew Ammoniated Superphos.	3.3	8	0	"	Passed	..	.5	.5	.9
J 8	Defender Fertilizer	3.3	8	1	No	"	..	.4	.6	.8
J 9	Drillwell Phosphate	2.5	8	1	Yes	Inferior	..	.3	.7	.8
J 14	Goodwill Ammo. Superphos.	4.1	8	0	"	Passed	..	.5	.5	.9
J 13	Innovation Ammo. Superphos.	2.5	8	0	"	"	..	.6	.4	.9
J 10	Log Cabin Guano	4.1	8	1	"	"	..	.4	.6	.8
J 11	Logical Compound	1.7	8	1	"	Inferior	..	.2	.8	.9
J 12	Penguin Ammo. Superphosphate	1.7	10	0	"	Passed	..	.4	.6	.9
	J. W. Sanborn									
L 8	Prof. Sanborn's Chemical Fertilizer for Grass and Grain	4.9	8	0	No	Passed	.4	.1	.5	.7
J 2	Prof. Sanborn's Chemical Fertilizer for Use in Hill and Drill.	2.5	8	0	"	"	..	.1	.9	.7
J 1	Prof. Sanborn's Chemical Fertilizer for Potatoes and Corn	3.3	8	0	"	"	..	.1	.9	.7
	Sanderson Fertilizer and Chemical Co.									
G 6	Atlantic Coast Bone, Fish and Potash, 1916	1.6	9	1	Yes	Passed	..	..	1.0	.9
G 7	Corn Superphosphate, 1916	1.6	10	1	"	"	..	..	1.0	.9
G 8	Potato Manure, 1916	2.1	8	1	"	"	..	.1	.9	.8
	Virginia-Carolina Chemical Co.									
D 15	Ammo. Bone Phos. for All Crops	1.7	10	0	Yes	Passed	..	.1	.9	.8
G 9	High Gr. Corn and Veg. Comp.	2.5	8	1	"	"	.3	..	.7	.8
D 16	Owl Brand Potato Fertilizer	1.7	8	1	"	"	..	.2	.8	.8
E 1	Plow Brand Fertilizer	.8	8	1	"	"	..	.3	.7	.9
K 14	Twentieth Century Potato Manure with 2 Percent Potash	4.1	8	2	"	"	.3	.1	.6	.8

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

VI. CONCERNING TILLAGE

By R. T. BURDICK,
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INTRODUCTION

A decade ago eleven pages of print were used in bulletin 123 to set forth "The Moisture Relations of the Soil." A single page was devoted to a brief discussion of irrigation and drainage while ten pages were given over to the consideration of tillage, including a discussion of the conservation of soil moisture, of the effectiveness and nature of capillary water, of plowing, harrowing and intertillage. Three years ago in bulletin 173 the few words which were presented in bulletin 123 were expanded into a complete article on drainage. Two years ago the half page given over to the discussion of irrigation was expanded into a twenty page article in bulletin 182. And now, in view of the fact that bulletin 123 has long been out of print, the time seems ripe again to discuss in the annual fertilizer bulletin the general subject of tillage and in a somewhat more ample fashion.

Any adequate presentation of the subject of tillage methods naturally deals with why and how, with when and what, but more especially with why and how. Hence it is that this article is divided into two chapters. The first deals with objects and results, with fundamental principles; the latter with agencies, that is to say tillage machinery. In the first portion recourse has been had on pages 55 to 62 to an article issued in 1909 in the first annual report of the State Commissioner of Agriculture, now out of print. This article, entitled "The Philosophy of Tillage," was the product of one of the writers of this present bulletin and hence can be properly lifted and reprinted.

Webster states that tillage is "the operation, practice or art of tilling or improving land for agricultural purposes." The use of mechanical agitation of the soil to aid in crop production was the first step taken by our primordial ancestors in their abandonment of hunting and fishing as means of livelihood. Today tillage is first among the factors affecting crop growth which are not inherent properties of the soil. The difference between no crop and a successful crop often can be traced to the adequacy or inadequacy of tillage operations. Soil fertility, soil moisture, soil organic matter and soil structure are the foundation of crop growth, but tillage is the tool with which this foundation is made true and effective if properly done or caused to crumble if but poorly done.

The art and practice of agriculture have risen, flourished and waned many times in the history of the human race. Just how important a part tillage or its lack played in these early fluctuations it is difficult to say. It would seem as if the Mesopotamian husbandmen, to whose inventive genius, skill and patience may be ascribed the wonderful irrigation systems which thousands of years ago made the barren valleys of the Tigris and Euphrates blossom as the rose, or the prehistoric farmers who built and watered the marvelous terraces on steep Peruvian hillsides, would have known how beneficial is the stirring of the soil; but if they did they have left no records as to their tillage methods.

Vergil sings the praises of tillage:

> **"Much more advantage to the swain it yields**
> **To use the rake than harrow sterile fields;**
> **Nor golden Ceres from the lofty skies**
> **Shall view his labor with regardless eyes.**
> **And who, athwart the furrows plows the plain**
> **Then breaks the clods obliquely o'er again,**
> **Turning his team, and by a frequent toil**
> **To obedience brings a disobedient soil."**

A lack of adequate equipment and of a clear knowledge as to the relationships between soil culture and crop growth hindered for many centuries the development of a successful tillage practice. Jethro Tull has been considered the father of modern tillage practice. In his day, manure was supposed to pulverize the soil rather than to supply plant food. He argued that since tillage also pulverized the soil it could take the place of manure. He invented a drill and so improved the plows and cultivators then in use as to secure more thorough crop intertillage. He advocated intertillage of cereals as well as of potatoes, root crops, etc.

1. OBJECTS AND RESULTS

It is well known nowadays that tillage is a most important factor in plant growth. It is employed—

1. To modify the structure of the soil, with a view of securing a fine crumb structure without clod or separate grains; an ideal easier appreciated in the abstract than secured in practice, for the reason that the moisture and humus content of a soil are the determining factors in the matter and they are not always at an optimum.

2. To cover stubble and rubbish; more easily done today with our modern plows than formerly when forked sticks were used.

3. To incorporate manure and fertilizer with the soil.

4. To deposit the seed under a covering of soil.

5. To leave the surface smooth for subsequent operations.
6. To incorporate organic matter with the soil.
7. To control the water content of the soil, and to lessen evaporation.
8. To develop and maintain a large effective depth of soil, thus promoting full root development.
9. To aerate the soil.
10. To promote the growth of favorable bacteria.
11. To destroy weeds.
12. To reduce destructive water and wind erosion.
13. To destroy insect pests.
14. To economize seed.

Every one of these fourteen functions of tillage bears a vital relation to crop production; yet most farmers forget twelve and think of but two—namely:

The fitting of the soil; and the combat with the weeds.

SOIL MOISTURE CONTROL

The functions of soil moisture in crop growth are not always well appreciated. Water functions in tillage operations as a lubricant. It occurs as a thin film around the individual soil particles. When the soil is stirred by a tillage tool its particles slip over each other or separate along the line of this film. If the film becomes too thick or, in more common parlance, if the soil becomes too wet, the soil particles move individually and not as a unit or collectively, and they slide into place because of the pressure of the tillage implement. The action of the tool under such circumstances is like that of the trowel on mortar, and the result is approximately that which follows the process of trowelling. On the other hand when the water dries out of the soil the individual soil grains become closely packed together and present a smooth hard surface, resembling that of a brick. Nothing but the slow action of frost and other natural phenomena can loosen the soil after it has become thus puddled and packed as a result of being worked when too wet. The writer once saw a field which had been plowed in the spring when it was too wet and had been disced and harrowed nine times; yet it was still in poor and lumpy condition, the clods being brick-like and of brick size. Yet this same field in other years had been prepared for planting by three workings, twice with the disc and once with the harrow, simply because soil moisture conditions were better. The finer silts, heavy loams and clays are injured most

when thus mishandled. The lighter sands and sandy soils do not suffer greatly because they lack a sufficient number of fine particles to bind them together when worked in an overwet condition.

If, on the other hand, the soil is plowed when dry and baked, the plow or other tillage implement tends at first to break the earth into large masses or clods. The soil particles are held together by the cementing power of the salts of the soil solution which were deposited as the water evaporated as well as by the binding power of the soil colloids, by the adhesion of the soil particles and the small film of water still in the soil, and by the cohesive attraction of the individual soil particles one for another, an attraction which is much more strongly exerted between fine soil particles than between coarse ones. The net result of the action of these binding agencies is so to consolidate the soil that it takes an enormous amount of power to break it up and loosen it. Anyone who has tried to plow an over-dry land thoroughly appreciates this fact. The soil holds tenaciously until it breaks into large masses, or, if the power is applied with a crushing action, the clods tend to crumble into a powdery, separate grain condition and the soil puddles with the first rain.

How can one tell when the moisture content of the soil is such as to favor success in tillage operations? By observation, by testing the soil with the hand. When it can be pressed into a mass that retains its shape upon releasing the fingers, yet can be crumbled again by pressure from one side, it is not too wet to work. This optimum water content often does not exist with heavy clay soils for more than a few days at a time. If considerable areas are to be broken up, either a large force of men, horses and equipment must be available, or else a greater or less portion must be worked when either too wet or too dry. This situation may be met in either of two ways. The heavier clays may be kept in meadow or pasture for as long a time as possible in order to avoid many workings; or they may be fall plowed when the moisture content is as nearly ideal as may be and then in the spring, when again in the optimum condition, they may be harrowed and otherwise fitted, thus handling a much larger area than would be possible if they were plowed solely in the spring.

The first working of the soil in the spring is a most important one. If some tool is used that covers a wide strip and passes but once in a place, the surface may be loosened and crumbled sufficiently to prevent it from baking into clods. Such a procedure tends to check the evaporation of soil moisture and to keep the soil in proper moisture

condition for a longer period of time. Then the field may be harrowed in final preparation for the seed, and a seedbed of fine tilth may be secured.

Where spring plowing of corn or grain stubble is needed, soil moisture may be conserved and the plowing period prolonged if the entire field is gone over with a disc harrow. This serves to loosen the surface enough to check evaporation. Then, if plowed and promptly reharrowed, a good seed bed should be secured.

Eastern farmers often fail to appreciate the importance of conserving the water supply of the soil. The growing seasons of 1913, 1914 and 1915 were relatively dry and then if ever tillage operations to save soil moisture were needed. Good crops were secured when the opportunity was embraced to conserve moisture and poor crops on nearby farms where tillage operations were ill done or not done at all. Fall plowing wherever possible; early spring plowing as soon as the soil reaches its optimum water content; harrowing promptly in order to form a mulch and to save all the moisture possible; and intertillage after each rain to restore the surface mulch; these were the cultural practices which ensured good crops. Late spring plowing; harrowing delayed until the surface soil was baked; and entire neglect to intertill the crops after rains; these were the cultural methods which ensured poor crops.

Nature is usually kind to the Eastern farmer. She seldom omits to supply him with enough rain to grow a fair crop, if he helps her by saving what her bounty gives. However, many farmers fail to make the most of their opportunities since complete crop failure rarely follows even extreme neglect. Good crops are often secured in sections like the semiarid West where the annual rainfall amounts only to 15 to 20 inches—which is much less than half of that with which we are blessed. The dry-land farmer plows deep, maintains a dust mulch over his soil to save moisture, and does everything in his power to ensure successful crop growth. The same energy and forethought applied in average eastern farming operations would greatly increase crop yields.

WEED CONTROL

Weeds consume space, plant food and moisture which belong to the cultivated crops. The older they grow the more serious are the losses which they cause. Yet some farmers seem to act as if they thought it was unmanly to destroy a weed until it has gained its growth and become a foeman worthy of their steel—in fact sometimes superior

to it. A weed, like any other plant, requires a root system and foliage in order to live. If either is removed the weed dies. It is a difficult matter as a rule to kill a full growth weed, but it is a simple matter to stir the soil and sever the root connection of small weeds which have just sprouted. It can be done in a wholesale and effective manner with a harrow or weeder; but if a heavy rain immediately follows, the root systems of the weeds may become reestablished. In such a case the harrow should be used as soon as the ground dries. Two such harrowings should eliminate practically every weed.

After weeds such as quack or witch grass, Canada thistle, wild morning glory and bindweed have established themselves, their vulnerable point is above ground. If the growth of stem and leaf is inhibited, the roots will starve and ultimately die. A thorough stirring with a tool that will cut some leaves and bury the rest is most effective to this end. The disc harrow or the sulky cultivator work well when the weeds are well developed; the spring tooth and smoothing harrows when they are just renewing their surface growth.

Weeds are thought to be a bane; but really they are often a blessing, in that they tend to stir the farmer to stir the soil. In so far as the presence of weeds leads to better tillage, they are a help rather than a hindrance. For example, if the smoothing harrow is used on a corn field a week after planting it is most effective in killing weeds; but is equally effective in renewing a surface mulch which will conserve moisture, and in a dry season the moisture thus saved may prove a large factor in the growth of a good corn crop.

"THE PHILOSOPHY OF TILLAGE

"Doubtless had it not been for the little episode detailed in one of the earlier chapters of Genesis in which our primal mother and the serpent took part, there might have been no need for this article on tillage. But since by the sweat of man's brow one's bread must be earned, the ground must be tilled before it yields its harvest. Inasmuch as there is not commonly held a full, all-round conception of the manysidedness of tillage operations; inasmuch as there is a tendency upon the part of too many farmers to look to artificial plant food rather than to developed plant food for the growing of crops; inasmuch as the ease with which commercial fertilizers may be bought and the inadequacy of farm labor tend to augment the neglect of tillage operations; on all these accounts it seems worth

while to set forth in some detail the service or rather the services performed thereby to the end that they may be the better done.

"The commercial fertilizer does but one thing. It furnishes available plant food for plant needs. If it is a good fertilizer, if it has been wisely chosen following the suggestions made in other portions of this bulletin, it may do that one thing very well; but it is only one thing. Tillage, however, as has just been said, has many sides. It does manifold things, things chemical, physical, biological. Tillage operations increase the fertility of the soil in that they make more available the plant food already present. Tillage modifies soil texture in that it makes more fine the soil particles. Tillage by modifying texture and increasing porosity enables the bacterial life of the soil to multiply. Tillage in conserving of soil moisture more perhaps than any other one thing promotes crop growth. And, finally, it discourages the growth of weeds. That tillage in some degree does what a commercial fertilizer does has not always been recognized. That fining the soil increases the surface exposure of soil particles, thus leading to their more ready solution which means increased plant food availability and augmented crop growth, all these have been appreciated for years; but that tillage has five talents where the fertilizer has but one has not been generally understood.

"Professor King, in his article on 'Tillage, its Practice and Principles,' in the Cyclopedia of American Agriculture, (Bailey) volume 1, page 379, develops in succinct form the essential and fundamental propositions relating to tillage. Quoting these from his article in very slightly modified form it may be said that tillage:

1. Secures a thorough surface uniformity of the field so that an equally vigorous growth may take place over the entire area.

2. Develops and maintains a large effective depth of soil, so that there shall be ample living room, an extensive feeding surface and large storage capacity for moisture and available plant food materials.

3. Increases the humus of the soil through a deep and extensive incorporation of organic matter, so that there may be a strong growth of soil microorganisms and the maintenance of a high content of water-soluble plant food materials.

4. Improves the tilth of the soil so that the roots may ramble and soil organisms wander readily and widely thus placing themselves in contact with ample supplies of food materials.

5. Controls the amount, regulates the movement, and determines the availability of soil moisture, so that there shall never be an excess or a deficiency of this indispensable carrier of food materials to and through the plant.

6. Determines the amount, movement and availability of water-soluble plant food materials present in the soil, so that growth may be both rapid, normal and continuous to the end of the season.

7. Converts the entire root zone of the soil into a commodious, sanitary living and feeding place, perfectly adapted to the needs of the roots of the crop and to the soil organisms, one which is adequately drained, perfectly ventilated and sufficiently warm.

8. Reduces the waste of plant food materials through the destruction of weeds and the prevention of their growth and through the prevention of surface washings and drifting by winds.

"A few words concerning each of these several propositions.

a. THE SECURANCE OF SURFACE UNIFORMITY

"In a region of uneven topography such as obtains in New England, it is quite impossible always to make an absolutely even and uniform seed bed; but as close an approximation to this condition as is practicable is worth while in the interests of a full stand. Few farmers appreciate the loss arising from the empty places in an uneven, irregular, poorly planted piece. All the costs except that of harvest are essentially the same whether the stand is an even or an uneven one. It costs as much to fit, to plant, to intertill, to fertilize an uneven stand of corn as one that has come well. Better seed, more adequate tillage, well chosen fertilizers, good under-drainage, anything which tends to promote evenness of stand is apt to be worth while.

"The means for the securance of this surface uniformity naturally varies with different pieces. On the newer lands the removal of stumps, stones, etc., necessarily precedes breaking, pulverizing, and smoothing. Many Vermont fields would grow larger crops of more even stand were they well under-drained. Some of them would be improved by irrigation. In some sections, but not to any extent in New England, attention must be paid to the prevention of surface wash and of wind drifting.

"All bits of refuse, etc., which would interfere with crop growth, should be turned under to the end that high degree of tilth should be obtained which will enable a uniform depth of planting; such, moreover, as will secure conditions favoring an adequate moisture content

and a plentiful supply of heat, a high degree of porosity, in short, that condition of loamy mellowness which is well understood to be best adapted to the germination of seeds, to the rapid forcing of a crop, and to the procurement of the highest productive capacity.

b. THE DEVELOPMENT AND MAINTENANCE OF A DEEP SEEDBED

"The seed is alive. It needs a place to live in just as much as the human being needs a house, or the horse and cow a stable. This mansion must be ample in size, sufficient to allow it to stretch itself. There must needs be a living room, a dining room, a kitchen and pantry in the soil for each seed, not to speak of a moisture storage which may be likened to the well. All these are furnished if the seedbed be deep. The living room is the place where the seed lives, establishes its roots, starts its stalk. Its dining room is the place where it gathers those mineral forms of plant food and nitrates which enable it, together with the carbonic acid gas obtained from the air, to grow to maturity. The kitchen is the work room in which the micro-organisms prepare and transmute the plant food stored in the pantry, getting it into such condition that it may be absorbed by the plant roots in their dining room banquet. The cistern or well is the storage of water whence the plant drinks. Possibly the reader may think these similes are forced: and yet the plant lives, breathes, eats, drinks, moves, and needs conditions and environment wherein to perform these functions as much as does animal creation. A neglected, ill-fed, poorly housed animal suffers; and so does a neglected, ill-fed plant in a poorly-tilled soil. If through inadequate tillage operations, an inferior dwelling house is afforded the crop, one into which it is difficult for it to send its roots, from which it is impossible to gain adequate moisture or food, it does not thrive and crop growth suffers.

c. THE INCREMENT OF THE HUMUS CONTENT

"Bulletin 135 discusses humus at considerable length. It was stated therein that humus benefits the soil by supplying nitrogen directly; by supplying phosphoric acid, potash and lime indirectly; by augmenting the water-holding capacity of the soil; by increasing its warmth and bettering its texture; and by affording protection for microorganic growth. The serious effects of a shortened humus supply upon the individual farm and upon the well-being of mankind as a whole were pointed out, as well as the effects of current agricul-

tural methods upon its maintenance. It was pointed out in this bulletin that the continued growth of tilled crops, the employment of rotation which does not include therein the growth of grasses and legumes, fallowing, deforestation, forest fires, and the continued use of commercial fertilizers, all tend towards the exhaustion of humus supply. The same is augmented, however, by a crop rotation which includes grass or legumes, by the use of farm manures, and by the practice of green manuring.

"The incorporation of organic matter into the soil where it may be transformed into humus is one of the most important functions of tillage. It is one of the main sources, sometimes the only source, whence nitrogen is conveyed to crop growth. This ingredient is the most expensive form of plant food purchased in commercial fertilizers. Moreover, as was pointed out in bulletin 130 at great length, it is the most evanescent of plant foods. Nature's methods and man's prodigality seem banded in a conspiracy to denude the soil as rapidly as may be of this valuable plant nutrient. It is, moreover, sold from the farm in considerable quantities in the form of milk, live stock, grain and in other ways. On this account it is vitally necessary that farmers appreciate the relationship of tillage operations to the incorporation of these nitrogen-containing materials into the soil.

d. THE BETTERMENT OF TILTH

"The person who stays at home all his life and never travels may be a very good man but he is not apt to be a broad one. Travel is one of the best means of education, of enlarging one's power for service. Similarly with the plant. A crop which is bound tightly in a poorly tilled soil so that its roots cannot spread widely cannot grow to that full stature which it should and might assume if its roots had a chance. An animal may move from place to place and seek food; but plants can only make use of the food which their roots can reach. The writer has sometimes likened this phase of tillage operations to a railroad ticket in that it permits the roots to travel.

"The relationship of the soil organisms to crop growth was discussed at length in bulletin 130. It is now thoroughly well understood that the soil is alive with bacteria, which functionate in crop growth and in the solution of plant food as well, in the preparation of the nitrogenous forms for crop service. Some of these organisms are helpful, some are hurtful; and the helpful ones are helped and the hurtful ones are hurt, speaking broadly, by adequate tillage.

e. THE CONTROL OF THE MOISTURE CONTENT

"Everyone appreciates the effect of a droughty or of an over-wet season upon crop growth. Either an excess or a deficiency of water spells disaster. In a country which is dependent for its soil water supply upon rainfall, tillage cannot absolutely control the water content of the soil; but it can go a good ways towards it. In central California where the soil depth is almost limitless, of great water holding capacity and where the seasons are divided into the wet and the dry, the writer has seen luxuriant vegetation in absolutely dry weather, after four months have elapsed without a rain drop. The moisture in the soil was kept from undue evaporation from the surface by the frequent intertillage of the crop. Under eastern conditions this matter may be controlled to some extent by proper attention to intertillage. In this connection see the matter on pages 52 to 54.

f. THE PROMOTION OF PLANT FOOD AVAILABILITY

"Neither plant nor animal is capable of making use of food, except in solution. It enters the animal's system through the intestinal wall and passes into the lymphatics and the blood. It enters the plant system through the wall of the root and in gaseous form through the stomata or breathing pores of the leaves. The chemistry and physiology of the construction within the animal and the plant structures of the complicated molecules which compose them is not a matter with which we are interested in this particular article; but the particular point to be made here is that the plant food must be made soluble before it is of the slightest service. The agencies of solution are many. The moisture of the soil, the microorganic life of the soil, the action of earthworms, soil acids, doubtless the acid exudates from plant roots, the effect of weathering; all these and doubtless others, perhaps some of which we have no notion, have relation to this important matter. But one point in particular is very clear, namely, that in proportion as the particles are made more fine, they present a larger surface area to the action of these various agencies and hence more plant food can be dissolved thereby in a given time. The writer has many times in presenting this matter orally, made use of the following illustration: Two spoonfuls of sugar contain the same amount of sugar as do two lumps; but if the spoonfuls be stirred in one cup of coffee and the two lumps in another, the two spoonfuls will be dissolved much more easily and quickly than will the two lumps,

simply because they offer a larger surface area to the dissolving fluid than do the lumps. Similarly with a soil. A fine soil is more fertile than a coarse one. The fining of soil by tillage is essentially the same thing as the furnishment of available plant food, in that it makes a larger proportion of the plant food naturally present available to crop growth.

g. THE PROMOTION OF SOIL HEALTHFULNESS

"It is a comparatively new notion that soils may become sick. Yet it is quite certain that this is the case. Soils sometimes become dyspeptic as it were; sufficiently acid in their character as to cause inferior forms of plant growth to thrive rather than superior ones. The causes for soil acidity are many. It may be due either to a lack of or to an excess of humus; to the over-usage of commercial fertilizers; to the leaching of lime from porous soils; or to other reasons; but we know that tillage to some degree and under some circumstances, is apt to better these conditions. Lime, however, is a more certain remedy.

"One school of soil investigators has, of late, broached the idea that soils get into an unsanitary condition through the accumulation of toxic or poisonous excretions; certain more or less unknown organic substances which become harmful to the further growth of the sort of plant producing them. They claim that a certain portion of the benefits which are derived from thorough tillage and intertillage should be ascribed to the aeration thus produced and to its effect upon these toxic bodies. Whether this claim is or is not entirely borne out in fact, it is certainly true that a soil which is poorly tilled is not one in which crops thrive. Such tillage operations as tend to promote adequate soil drainage, soil ventilation, and the entry of a sufficient amount of heat aid in the bringing about of a more healthful condition of the soil and in the promotion of crop growth.

h. THE REDUCTION OF WASTE DUE TO WEED GROWTH AND EROSION

"The common conception which farmers hold as to the underlying reason for hoeing crops, of running the horse hoe, the weeder, the cultivator, is that it is done in order to kill weeds. The weed killing proposition is important but subsidiary. A much more vital matter is the saving of moisture to the crop by the breaking up of the capillary tubes, the lessening of evaporation, and by the removal of a class

of growth which is an avid user of water and of plant food. (In this connection see the matter on pages 54 and 55).

"The relationship of tillage operations to the prevention of erosion was discussed at considerable length in bulletin 135. It is stated therein that while this proposition is not an important one under New England conditions, in certain sections the relation of tillage operations and of tillage instruments to the control of this situation is important. A deep soil which provides a large chance for rain storage and one in which deep rooting crops like clovers may be grown; a soil which is bound together with a dense growth of grass roots; a soil which is well stored with humus by the use of farm manures, the practice of green manuring, and of grass growing; all these are conditions which tend to lessen the extent of devastation by surface washing or wind sweeping. So long as Vermont remains primarily a dairying region, we may not fear that the fate of Palestine or of Mississippi will be hers. Thanks to the cow, to grass, and to clover, her hillsides will remain green for generations."

2. Tillage Machinery

Tillage machinery is roughly divided into two classes, namely, tools that move the soil either by its inversion or by stirring—and these are the more common sort—and those that compact the soil. Among the former are included plows, harrows, planters, cultivators, weeders; among the latter, rollers and plank clod crushers.

Tillage Tools Which Invert or Stir the Soil

THE PLOW

The earliest records of agriculture mention the plow. In its primitive form it was simply a natural fork from a tree drawn by women, or later, by oxen. Then iron strips were fastened over the point in order to check the rapid wear on the wood (Samuel 13: 20). The action of these early plows was similar to that of the modern cultivator teeth. Improvements followed in due time which increased the penetration and lifting power of the plow. At first the furrow was pushed to one side, much as snow is pushed aside by an A plow. In 1720 Foljambe of Yorkshire, England, secured a patent on a plow that had "vertical and horizontal wedges combined in a moldboard and connected by a curved line so that the furrow slice was first raised a little and gradually inverted clear of the space in which it lay." The

form of the moldboard was modified still more, especially by Small and Wilkie of Scotland and by Thomas Jefferson. In 1785 an Englishman named Ransome secured a patent for making plows of cast iron and, eighteen years later, he patented the method of case hardening or chilling shares. Among those whose names are writ large in the annals of plow history in the United States may be mentioned those of Wood, Stevens, Nourse, Mears, Knox, Deere, Lane and Oliver; and it is of interest to note in this honorable company the name of one of Vermont's war governors, who lived to a ripe old age and who has but recently passed from among us—the late Ex-Governor Frederick Holbrook of Brattleboro.

The plow now has reached a high stage of development. Special forms of moldboard and share have been adapted to every conceivable condition of soil. "The modern plow has wrested an abundance from the soil. Animals harnessed to it have freed the peasant from the heaviest of all tasks and given him leisure to advance in knowledge. The world now rests in confident anticipation of the farm's certain surplus. Civilization and the plow have gone together, and whatever advancement of humankind we may look forward to will surely be paralleled by perfection now unattained in that noblest of instruments. Fitting it is that the United States Government should place the plow prominently on the great seal of the Department of Agriculture" (12).

The types of moldboards found today are best illustrated by the common walking plow. Three types are recognized. There is the breaker or sod plow with its long, slow moldboard twist, used to turn an unbroken sod furrow. There is, at the other extreme, the stubble or old land plow, its moldboard turning at a very abrupt angle, throwing the furrow sharply to one side and crumbling to the *n*th degree. And, midway between these two types, there is the general purpose plow which does not pulverize old land as much as does the stubble type, but can be used to fair advantage on all but the toughest sods. The general purpose plow serves a good purpose on most Vermont soils, the sod plow does best on heavy clay soils, and the

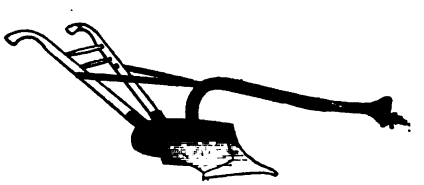

FIG. 1. A two-horse turning plow, a type used throughout the corn-belt states.[1]

[1] For this and succeeding cuts, reproductions of some of those used in Federal Department Bulletin 320, the Station is indebted to the courtesy of the United States Department of Agriculture.

stubble plow is used most frequently on the lighter sandy soils, putting the ground in such a condition that it usually requires very little further treatment before planting. It sometimes does better work on heavy clays than the sod plow, but its draft increases out of proportion to the added work done, and hence it is not to be recommended. Furthermore it presses so firmly against the furrow in twisting it to one side that if a soil is over wet the moldboard slickens and puddles the surface more than do the sod and general purpose types.

More of the plows in use today are walking plows of one or the other of three types. The back furrows and dead furrows it causes are undesirable, particularly on land that is well drained, but they often are a distinct advantage on level and poorly drained land since they act as shallow surfaces ditches.

The walking plow is disadvantaged on rolling land in that it does not turn a furrow uphill. This necessitates plowing up and down the slope, which requires the expenditure of more power. The hillside plow overcomes this obstacle. Its moldboard and share are hung by a swivel to the plowbeam and can be locked so as to turn a furrow either to the right or to the left. Because of this double construction of share and moldboard a rougher furrow is turned than when the walking plow is used; but the effectiveness of its pulverizing action is not lessened, and we must remember that that is what a plow is used for—to pulverize the soil. Where drainage conditions are good, level fields have followed its use. Indeed it is being used largely on irrigated farms in the West and is becoming increasingly popular.

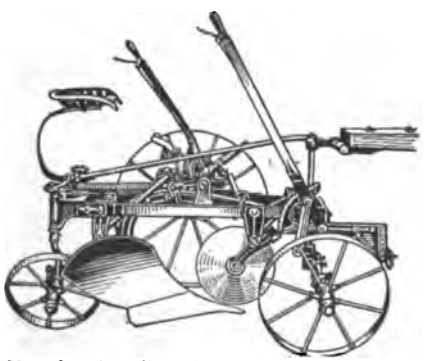

FIG. 2. A sulky plow (for either two or three horses), used in the corn-belt states.

The reversible sulky plow is really two separate plows in one, a right hand and a left hand, so hung on a frame that one plow can be used while travelling in one direction while the other is held free from the land and vice versa. Any moldboard type can be used. It works better than the hillside plow on level land.

Sulky plows, either one or two bottom, are not common in Vermont. The one-way sulky turns a steadier furrow than the walking plow, but its cost is relatively

high. The two bottom sulky requires four or five horses and is adapted to use on our large level fields or valley farms. Clearly the field of the two bottom sulky is not large in a state topographically irregular as is Vermont. The gang plow with two or more shares is a development of the sulky form. These are drawn mostly by traction engines. A diminutive gang of three bottoms, each capable of turning an eight-inch furrow to a depth of three to four inches has been developed for shallow cultivation in orchard work. It can be handled by two horses.

The subsoil plow consists of a long, thin shin or upright with a narrow share and frame but no moldboard. It is used to follow in the furrow of a walking or other common plow and raises and loosens the soil to a depth of eight to twelve inches below the furrow. Where the subsoil is dense and hard this tends to improve aeration, drainage and general root development. However the moisture conditions of the soil must be made right if one is to succeed in the use of the subsoil plows. If one waits in the spring until the subsoil is dry enough to make subsoiling safe, the surface soil will be usually too dry to be plowed to advantage and, furthermore, will have lost much of the moisture that is needed for crop growth. Then, again, loosening the subsoil in the late spring tends to cause the formation of large masses that may serve to impede the capillary movement of soil water. Under such circumstances crops are likely to suffer for lack of moisture. If, however, the soil has time to readjust itself after the subsoiling has been done, and if the soil masses can again crumble before the crop is planted, it may be worth while to practise subsoiling. In such a case it should be done in the fall so that the larger clods may become disintegrated through the action of winter's frosts. The subsoil plow has never been and seems likely never to be widely popular in these regions. Subsoiling is not a practice which as a rule is adapted to Vermont conditions. It is primarily a practice suited to semiarid and not to humid lands.

The disc plow, either as a single or double disc sulky, has enjoyed only a limited vogue in this section.

FIG. 3. A gang plow (for four or five horses), used in the corn-belt states for breaking land.

The diameter of the disc is usually from 22 to 26 inches, and it turns a furrow which is from 6 to 10 inches wide. This form of plow will cut through and break up a dry soil better than does a moldboard plow, but a considerable weight is needed in order to keep the plow in the ground. A sticky soil which will not scour a moldboard plow can be turned successfully with a disc. Except for dry and sticky soils the moldboard plow is to be preferred, for it handles easier and requires slightly less draft.

The deep tilling machine is a modification of the disc plow, consisting of two discs set so that one travels in the bottom of the furrow made by the other. In this way a furrow 12 inches wide and 15 to 18 inches deep is turned, using four or five horses. This plow does not stir the soil quite as deeply as does the subsoil plow, but it crumbles it in a much more satisfactory manner. It is said that considering the work done its draft is not excessive (9).

PLOW ACCESSORIES AND THEIR ADJUSTMENTS

The coulter or knife helps in cutting the landside of the furrow. The fin coulter, fastened to the share and extending upwards free, works well on sod lands but cannot be adjusted to the conditions met in different soils. The more common form is the so-called standing coulter, consisting of a knife fastened to the beam and extending down towards the point of the share. Its position affects both the draft and the operation of the plow. It should be so placed that its point is located about one and one-half inches back of and a half inch above the point of the share, and it should slope back so that when in use it runs under the turning furrow instead of dragging through in a perpendicular position. When it is thus set the share lifts the soil slightly before it is cut by the coulter. If the coulter is set too far back, the share tends to tear the furrow from the landside before it is cut, thus increasing the draft. Its vertical position is also important since both the width of furrow and the "running" of the plow are thus affected. In general the coulter should cut as nearly as possible a vertical edge at the landside, at a point about a half inch to the landside of the plowpoint. If a plow scours poorly and the coulter is set so as to cut about one inch into the land, the added width of the furrow by its greater weight may cause the moldboard to scour satisfactorily. If the coulter is set so that it is twisted either towards or away from the land, it tends to act as a rudder and to cause the plow to climb and swing from side to side, regardless of the adjust-

ment of the clevis. It can be brought into line by wedging the shank of the coulter against the beam.

The rolling coulter consists of a flat thin disc set to cut in the position usually occupied by the standing coulter. It may be placed on a rigid or on a swivel shank, the latter being preferable. It is thinner than the knife coulter, offers slightly less resistance to the soil and, being sharper, cuts with less draft. It rolls over trash instead of catching in it as does the standing coulter, and, being self-aligning, does not tend to run the plow out of line. On stony soil, however, it rides over the stone and thus tends to jump the plow from the ground.

Sanborn (21) states that the draft of a plow is increased by the use of any form of coulter, because the friction surface is increased. He holds that this increment fully offsets the advantage derived from cutting the furrow.

The jointer, a modification of the coulter, consists of a diminutive plow that turns a furrow one and a half to two inches deep on the edge of the regular furrow in such a way that when the main furrow is inverted the edge is turned out of sight. In plowing sod land which must needs be promptly prepared, the use of this device serves to cover all sod and aids in the formation of a mellow seedbed. It is a helpful adjunct in covering trash. Its adjustments are similar to those of the standing coulter.

The gage wheel is placed at the end of the plowbeam to assist in controlling the depth of the furrow. When rough and stony land is being plowed it throws the plow up and down enough to offset whatever advantages accrue from depth control. It is sometimes said to its detriment that depth of the furrow is apt to be adjusted entirely by means of the wheel instead of by the clevis—an undesirable result. However, the plow runs easier when the gage wheel is properly used and its draft is reduced.

A covering chain is of considerable help where tall rank weeds or cover crops are to be turned under. It consists of a short length of common chain fastened at one end to the furrow clevis of the evener and at the other end to the plowbeam just back of the coulter, with slack enough to allow the chain to drag on the ground.

ADJUSTMENTS OF THE PLOW

The ability to turn a smooth even furrow is determined quite largely by the proper adjustment of the line of draft between the source of power—the horse's shoulder—and the center of application—

the point in the plow around which the draft is equal on all sides. This center of draft in the plow varies with the depth and width of furrow, as well as with the nature and condition of the soil and the shape of the plow. "On stubble and general purpose plows it will be close to the shin (or front edge of the landside) and to the junction of share and moldboard. On plows designed for breaking tough sod at a shallow depth it will be closer to the point and the sole. Professor Gilmore, (formerly) of Cornell University, states that it is located behind the moldboard and two and one-half or three inches from the wall and sole of the furrow" (12). The hitch at the clevis can be adjusted either horizontally or vertically; but no matter where the hitch is the line of draft will tend to straighten, that is to say, to assume a straight line when the horses apply their power. Thus if the hitch has been made too far to the left side of the clevis on a right hand plow, the end of the beam will swing to the right in order to straighten the line of draft, and as a result the plow will "run away" from the land and cut a narrow furrow. To offset this tendency the plowman will have to "ride" the right handle. Similarly if the hitch at the clevis is too far to the right the plow will be swung into the land and take a wider furrow than it can turn while the plowman will be forced continually to "ride" the left handle. If the hitch is too low in the vertical adjustment on the clevis it will raise the end of the beam and the plow will not keep its depth. If too high at the clevis, the plow will "ride on its nose" and tend to plunge too deeply into the soil. When these adjustments are correct the plow will move straight ahead. Indeed, in a mellow soil it will keep its place without attention from the plowman, except when encountering a root, stone or other obstruction. In no way is a plowman's skill more clearly made manifest than in the manner in which he is able accurately to make these adjustments.

Another adjustment that affects the team more than it does the plow is caused by the straps which are provided at the rump for holding up the traces when the horse stands. If these are too short an angle is formed at this point and the horse pulls down on his back to no profit. Sanborn (21) found "the downward pull at this point to equal 50 pounds or one-third the pulling power of an average 1,200 to 1,500 pound horse—a third of the animal's power was being used to gall and annoy it instead of being applied to the work in hand."

The condition of the point and the cutting edge of the share also affect the service a plow can render. A worn or rounded point should be renewed; a dull share edge ground or replaced. When shares are

heated and pounded thin on the edge, their former lines are not readily restored. It often happens that a reforged share, though sharp, affects the draft of the plow as unfavorably as before sharpening, for the reason that it has been warped out of line. A new plowshare when set on a straight board should touch at the point, at the heel or wing of the share, and at the heel of the landside; and at the center it should be an eighth of an inch above the board. This curvature is called the "suction" of the plow and tends to keep the point in the ground, and it should as far as possible be retained if the share is resharpened.

DRAFT OF PLOWS

Gould (14) in the Utica plow trials of the middle of the last century found that 55 percent of the draft of the plow was due to the work exerted in cutting of furrow slice, 35 percent to the friction of the plow against sole and furrow and only 10 percent to the work exerted in lifting and turning the furrow. Sanborn (21, 22) found that when the plow was so adjusted as to cut either wider, narrower, shallower or deeper than the normal adjustments of the plow contemplated an increase of from 15 to 20 percent in the draft per square inch of furrow ensued and that poorer plowing was accomplished.

Ocock (19) studied the relation of wet, of dry and of good soil conditions to draft when using different types of plow. The following tabular statement is drawn from his publication:

Depth of furrow in inches	Dry soil		Wet soil		Good condition	
	Total draft	Draft per sq. inch	Total draft	Draft per sq. inch	Total draft	Draft per sq. inch
FOURTEEN INCH TURF BOTTOM PLOW						
4	291	4.61	295	5.26	241	4.31
5	318	4.54	370	5.26	296	4.26
6	318	3.92	330	3.92	353	4.20
7	413	4.26	423	4.31	406	4.14
8	436	4.20	478	4.26	430	3.83
SIXTEEN INCH TURF BOTTOM PLOW						
4	331	5.18	303	4.68	298	4.68
5	331	4.14	341	4.29	360	4.50
6	481	5.01	433	4.51	418	4.36
7	510	4.55	485	4.66	468	4.17
8	571	4.46	523	4.09	518	4.04
FIFTEEN INCH STUBBLE AND TURF BOTTOM PLOW						
4	318	4.96	355	5.59	300	4.58
5	393	4.91	393	4.91	370	4.62
6	445	4.31	415	4.38	435	4.53
7	503	4.48	483	4.31	525	4.09
8	570	4.45	546	4.24	525	4.09
FOURTEEN INCH STUBBLE BOTTOM PLOW						
4	315	5.62	285	5.09	275	4.91
5	383	5.47	330	4.57	310	4.43
6	555	6.54	380	4.52	360	4.28
7	596	6.08	435	4.44	410	4.18
8	548	5.19	502	4.53	450	4.02

This table is typical of available draft data. Clearly total draft increases with depth and width of furrow, but draft per square inch cross section of furrow decreases as the depth of furrow increases. In other words a given volume of soil is moved more economically in a deep furrow than in a shallow furrow.

Much work yet remains to be done in testing the draft of plows and other tillage implements, but enough has been done to show the importance of proper adjustment. Since half of the power required to draw a plow is used in cutting the bottom and side of the furrow slice, obviously it is highly desirable that coulters and shares should be in prime condition and be properly adjusted.

CHOICE OF PLOW

When the furrow is inverted by the plow the entire furrow slice undergoes shearing strains that tend to crumble the mass. This action of the moldboard can be illustrated by taking the leaves of a book in one hand and bending them sharply to one side. The leaves are seen sliding past each other for the reason that they represent circles of unequal diameter. Those on the inside are curved around a much smaller circle than those on the outside. This same action takes place as the furrow is turned by the moldboard. The bottom of the furrow has to travel farther than the top and the entire mass tends to separate into aggregates of various sizes. The deeper the furrow the greater the internal strain developed, because there is a greater difference in the distance travelled between top and bottom of furrow. The stubble plow with its abrupt moldboard emphasizes this action, consequently it pulverizes the soil much more thoroughly than does the slow-turning sod plow. If a soil is too wet when this shearing action takes place the soil particles tend to slip past each other and pack into a dense puddled mass. It follows then that when it is necessary to plow a soil which is too wet it should be disturbed as little as possible. A shallow furrow turned with a sod plow meets this condition. If on the other hand the soil is too dry when plowed it is desirable to pulverize it as much as possible in order to prevent the formation of large clods. This may be done—if there is power enough available—by using a stubble moldboard and by plowing deep.

DISC HARROWS

The disc harrow is second only to the plow in tillage operations. It inverts and pulverizes the surface three or four inches of soil in the

same way as the disc plow does to greater depths. Indeed sometimes no plowing whatever is necessary and the disc harrow is the first tool used in preparing the seedbed.

The full bladed disc has solid perfectly rounded edges. It is the best form of this implement for general purposes for the reason that it exerts a greater pulverizing action, cuts up trash better, and can be more easily sharpened than other forms. The disc is usually 16 inches in diameter. A disc of this size penetrates the soil easier than does one of a larger diameter, because it has a smaller bearing surface on the ground. Furthermore it turns over more times in travelling a given distance, thus tending to pulverize the soil more effectively. Eighteen and twenty-inch discs are less desirable, although they are more durable. However, if set at a sharp angle they can turn the soil deeper than the smaller discs and more successfully replace the plow. Sizes smaller than 16 inches do not afford sufficient space below the axle.

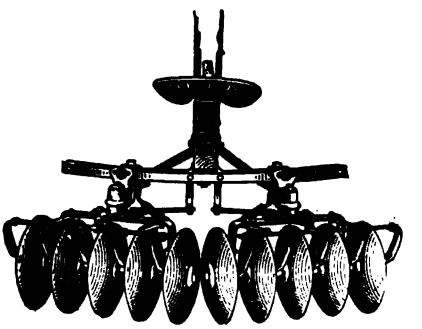

FIG. 4. A disc harrow, extensively used for seedbed preparation following plowing.

Three horses should be used on a twelve-blade disc harrow for the reason that the harrow cannot be set to do as effective work when only two are used unless the driver walks, as the extra weight causes greater penetration than the team can effectively cope with.

The cutaway disc is similar to the full bladed except that notches are cut out of the edge of the disc. Davidson (9) states that "the cutaway harrow is very deceiving in the amount of work it does. The blades sprinkle the soil over the surface in such a way that the unstirred soil beneath is hidden. This harrow has a decided advantage in cultivating and renovating old pastures. Where the full-bladed disc would cut the stubble up and destroy it, the cutaway will loosen the soil in such a way as to stimulate growth."

The spading disc harrow is a further development of the cutaway in which a series of curved blades are fastened in the form of a wheel. It has nothing to recommend it for general use except the fact that it can be used in wet ground when the full disc harrow would clog. It is a question whether or not it does more effective work than the

cutaway and certainly it is somewhat more complicated in its construction.

In adjusting the disc harrow it is desirable to have a lever for each gang of discs so that they can be set at different angles whenever necessary. The tongue truck is also desirable for it does away with the necessity of lashing of the tongue on the horses' necks. Some farmers object to the tongue truck because the harrow is difficult to guide when travelling on the road and there is greater danger of getting the team tangled in the harrow when turning. A tongue fastened to the tongue truck will overcome these objections.

The double disc harrow is gaining in popularity wherever large fields occur and sufficient power is at hand. It consists essentially of two harrows in tandem. By setting one to throw each way the ground is worked twice and left in level condition. At least four horses are needed to do satisfactory work. The reduction in time in which one man can cover an acre when using this implement makes it a paying investment.

HARROWS

The first harrow was doubtless simply a tree limb; then short sticks were fastened to the limb in order to improve its action; and, later, the "A" drag was developed. There are two common types now in use—the spring-tooth and the spike-tooth or smoothing harrow.

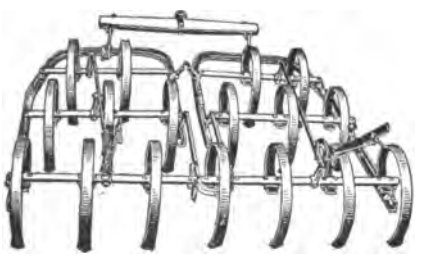

FIG. 5. A spring-tooth harrow, largely used for seedbed preparation following plowing.

The spring-tooth harrow is used in some cases for the first working of plowed land. It is less efficient than the disc harrow in proportion to the power required. It does not work well on sod land for the reason that it brings sod and trash to the surface. It is seldom used to follow the disc harrow since it leaves the soil surface in too uneven a condition. It loosens a compact soil and does a large amount of work. It does better work than the smoothing harrow on soil infested with quack grass roots, but is less effective than the disc, especially if the latter is weighted in order to hold it down into the soil.

The spike-tooth or smoothing harrow is used on practically all Vermont farms. It finishes the pulverization and leaves the soil sur-

face in good condition for the seed. By setting the teeth so that they slope to the rear it can be used as a weeder after the crops are planted and as a means of rapidly establishing a soil mulch.

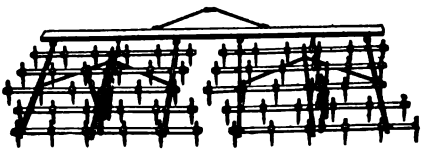

FIG. 6. A spike-tooth or smoothing harrow, in general use for seedbed preparation following plowing.

A harrow's teeth should be sharp and should number from six to nine for every foot of width. The more the teeth, the better the result of stirring of the soil. When they become dull they can be reversed.

A sulky harrow with teeth resembling those of a cultivator is used quite frequently in harrowing up old land and in orchard cultivation. The teeth can be gaged for depth by levers. The combined weight of the implement and the rider so depresses the teeth that they tear up the soil very effectively.

FIG. 7. An Acme harrow, an excellent pulverizer.

PLANTERS

The action of the implements used in planting should not be overlooked. The grain drill with hoe furrow openers is quite an effective harrow; broadcast seeders possess a set of regular harrow teeth; and corn planters, potato planters and transplanters in a small way are of service.

CULTIVATORS

The harrow is of use chiefly as a means of reducing the soil masses and developing a fine seedbed. The cultivator is used primarily to destroy weeds and preserve a surface mulch. Some farmers use the cultivator to complete the preparation of the seedbed which has been but half finished when the crop was planted. This is not an economical procedure for the reason that the one horse cultivators which are commonly used cover very narrow strips. There are cases where regular harrows and other tillage implements can be used essentially as a cultivator immediately following planting with a view of killing weeds and maintaining a mulch rather than of pulverizing

SEVEN TYPES OF CULTIVATORS

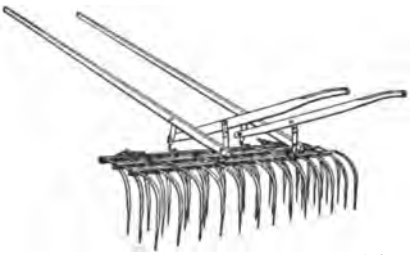

FIG. 8. A weeder, used in early cultivation.

FIG. 9. A one-horse spike-tooth cultivator.

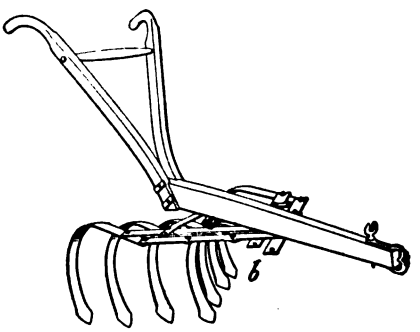

FIG. 10. A one-horse, spring-tooth cultivator for stone-free land.

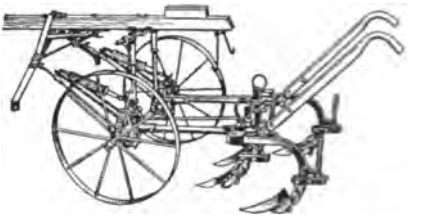

FIG. 11. A two-horse, four-shovel corn cultivator.

FIG. 12. A two-horse, six-shovel corn cultivator.

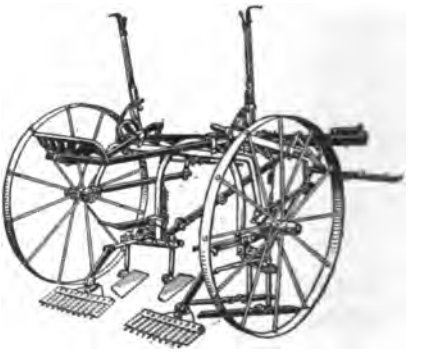

FIG. 13. A surface cultivator with 4 long sweeps.

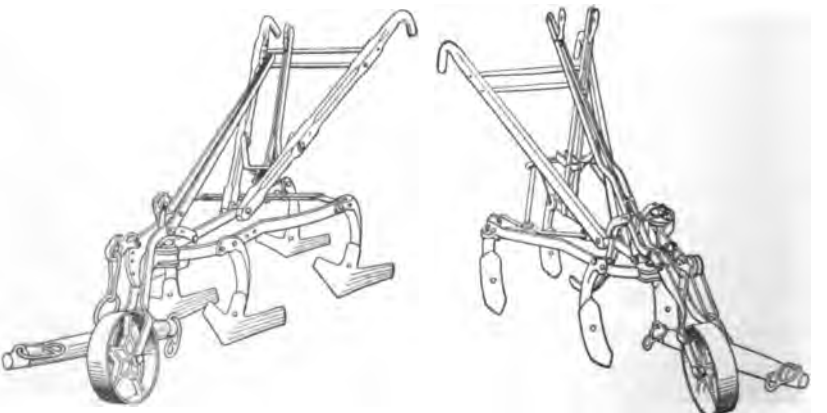

FIG. 14. A one-horse, five-shovel corn cultivator; left hand with sweeps; right hand, with shovels.

the seedbed. The weeder is usually preferred for this latter use, as it has finer teeth than the harrow, is of lighter draft and usually leaves the surface in a finer condition. The weeder can be used until corn or potatoes are about three inches high, but cannot be used on beans after they begin to come through the surface for the stems are brittle.

One horse walking cultivators were once the chief type, but are less popular than formerly owing to the development of the sulky cultivator. They can be purchased in many styles and forms. The earlier forms had two or three large teeth; later four and five slightly smaller teeth were used; and now ten to twelve small teeth are generally employed. The early forms did quite a little of the preparation which was not done before seed planting, and the large teeth were useful in digging out weeds which had gained a foothold. Two tooth cultivators are still used in the South. However, the development of better tools for the preparation of the seedbed, and the spread of the idea that weeds should be killed when small, has wrought a change. The small teeth stir the surface soil more effectively, kill all the weeds and leave the surface in a smooth condition. When much hand hoeing has to be done, the large teeth perhaps are helpful, in that they dig up the soil so it can be hilled up with the hoe. But better methods of weed control by horse machinery have done away with much of the hoeing considered so essential in the early days, which frequently reached its climax on the Fourth of July or on the hottest day in the month.

The one- and two-row sulky cultivators permit one to cultivate much closer to the row than is possible when using the one-horse cultivator, unless it is used twice in a row. Their introduction enables one to handle many more acres and to keep them cleaner than was formerly done by hand. The riding cultivator may be equipped with shovels, sweeps, or a small disc gang. The shovel type is most commonly used in Vermont, although the disc is not unknown. It depends for its action upon its ability to throw the soil to one side; hence it either hills the row or pulls soil away from the row. The sweep consists of long, nearly level blades fastened in the middle, so set as to scrape about one inch under the surface. It is very effective in killing weeds and developing a mulch and it should be more widely used than at present.

DEEP OR SHALLOW CULTIVATION?

Shallow cultivation destroys young weeds and maintains a surface mulch which to be effective in this climate need be but two inches

deep. Shallow cultivation is usually to be advised; however, during the first few weeks of growth a deeper cultivation will serve good purposes in that it aerates and warms the soil and hastens crop development. But when the roots begin to spread, the cultivator teeth breaks them if deep cultivation is practiced. This makes it necessary for the plant to send out new roots before it can develop fully its leaf and stem structure. The larger the plant at the time when the roots are broken, the more serious is the result. In fact one of the reasons why late cultivation of corn and potatoes often fails to benefit the crop is that the cultivator teeth are set too deep.

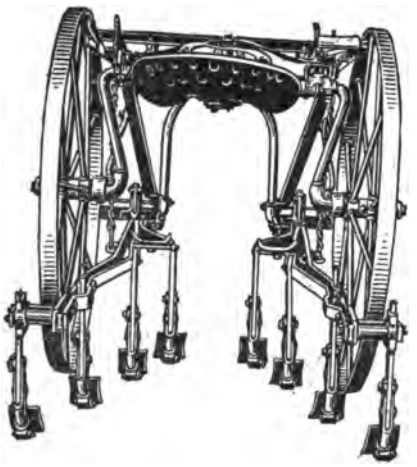

FIG. 15. A two-horse, eight-shovel sulky cultivator.

A farmer was once showing the writer a fine growth of silage corn which was receiving its last cultivation with a one-horse five-tooth cultivator. When the farm hand lifted his cultivator to turn around at the end of the row a festoon of fresh corn roots hung on each tooth. The farmer, remarking that he never supposed a cultivator could do so much damage, hurried it to the barn. On another farm two men were sent one day to cultivate a field of potatoes in blossom. One had a twelve-tooth cultivator with the wheel raised, so it let the teeth about four inches into the soil; the other, a cultivator with blunt teeth that rode up on the soil, giving about two inches penetration. They began in the middle of the field and worked both ways. About a week later the part of the field covered by the first man began to turn brown and to show all the signs of maturity, while the remainder of the field was green and vigorous. The deep cultivation apparently had severed many of the

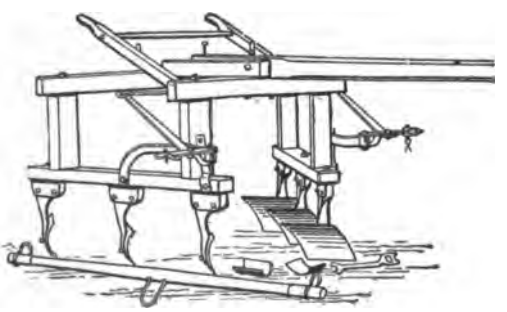

FIG. 16. A two-horse cultivator with scraper instead of shovels.

potato roots and the plants did not have vitality enough to put out new roots before they were shriveled by the sun.

One can determine for himself how deep it is safe to cultivate, by digging down around a plant and finding the first branching roots, and by setting the cultivator to stir the soil at a depth a little less than that at which the roots are active, being careful to set the teeth near the row about an inch shallower than those located in the middle between the rows.

When a corn plant is three feet high, the soil will be practically filled with roots for a distance of two feet on all sides and to a depth of six to eight inches. But little water can get past such a network of roots. But during the early growth and until the plant is eighteen inches high, much soil moisture may be lost by surface evaporation between the rows. Hence the cultivator should be at work often during early growth and cease its activities when the crop reaches a height of thirty inches or more. The depth, time and frequency of cultivation play important parts in producing a good crop.

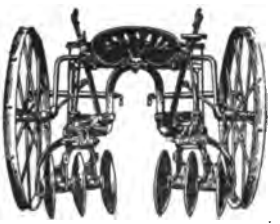

FIG. 17. A two-horse, disc, sulky cultivator.

The Federal Department of Agriculture in its recent (1916) bulletin 320 discusses "Farm Practice in the Cultivation of Crops." Its study was made in twenty different states, located mostly in the corn belt and in the South. The results secured in central Connecticut, in northern Pennsylvania and in central Wisconsin seem fairly applicable to conditions in Vermont, although it is stated in the bulletin that the corn grown in the Connecticut area was in a region where tobacco farms are common and that the tillage methods used in connection with the corn as a rule were those best suited to the growing of tobacco. In each area the tillage practice of from 25 to 30 farmers was carefully studied, more particularly as to the depth of plowing; the nature and number of the tillage operations done after plowing and before planting as well as of the tools used; the nature and number of the tillage operations carried on subsequent to planting; the kind of tillage tools used, the order in which they were, and the extent to which they were used; and, finally, the acre yields were determined in terms of bushels. All these data were accurately secured, the entire study in each case being made on the ground.

It goes without saying that divergence of practice was discovered as between different localities and as between farms in the same region as may be noted in the following tabulated statement. There seems to be no very close connection between high yields and the tillage practice back of these yields on the one hand, and relatively low yields and the tillage practice back of them on the other hand. For example, one Connecticut farmer tilled his crop after planting but once with a two-horse, eight-shovel cultivator. The average number of workings of the soil after planting in the Connecticut area was 3.8. The crop yield where but one cultivation was carried out was exactly the average yield for the entire region. Another farmer in the same section plowed two inches deeper than was done in the case just cited, apparently fitted his land about as well, and cultivated it six times after planting instead of but a single time; and the bushel yield was identical with his neighbors. A study of the tables in the federal bulletin indicates that in general there seems to be no correlation between much tillage and high yields or less tillage and low yields. In short, it seems evident that the tillage factor was not the only one responsible for the crop; that the state of fertility, for example, was also an important item, or, perhaps, the condition of the land as regards drainage.

The following table concisely sets forth the results of these three studies.

	Connecticut		Pennsylvania.		Wisconsin	
	Extremes	Mean	Extremes	Mean	Extremes	Mean
Depth of plowing..	6 to 10 inches	7.4	3 to 8 inches	6.1	4 to 6 inches	5.5
Tillage after plowing and before planting	2 to 3 times	2.4	1 to 5 times	2.5	1 to 3 times	1.8
Tillage after planting						
Harrow and weeder	1 to 3 times	0.8	1 to 3 times	0.2	1 to 4 times	2.
Cultivator	1 to 5 times	3.	1 to 8 times	4.2	2 to 4 times	3.4
Total	1 to 6 times	3.8	2 to 8 times	4.4	4 to 8 times	5.4
Crop	17 to 60 bush.	39.9	25 to 50 bush.	38.2	20 to 50 bush.	30.4

It is interesting to compare the implements used in these three sections as judged by these surveys. The Acme harrow was used by 36 percent of the Connecticut farmers, while it was not used at all by the farmers whose tillage practice was under study in northwestern Pennsylvania, or in central Wisconsin. The disc harrow was used by 76 percent of the Connecticut farmers, by 4 percent of the Pennsylvania and by 69 percent of the Wisconsin farmers; the spike tooth harrow by 72 percent in Connecticut, by 29 percent in Pennsylvania

and by 100 percent in Wisconsin; the spring tooth harrow throughout the Pennsylvania and nowhere in either the Connecticut or the Wisconsin areas; the plank drag by two of the farmers in the Connecticut area and by one in the Pennsylvania area; the roller was used by one Pennsylvanian and not elsewhere. The Connecticut farmers on the average worked their land 2.4 times after plowing and before planting, those in Pennsylvania 2.5 times, those in Wisconsin 1.8 times.

After planting, 20 percent of the Connecticut farmers went over their fields with the spike tooth, and 96 percent of the men in Wisconsin did likewise; but this tool was not used in the Pennsylvania area. Forty percent of the Connecticut farmers used a weeder, 14 percent of those in Pennsylvania and 54 percent of those in Wisconsin.

In Connecticut, 48 percent of the farmers used a one-horse, one-row, spike tooth cultivator; 56 percent, a two-horse, one-row cultivator with scraper—similar to the Prouty hoe commonly used in Vermont; 24 percent, a two-horse, eight-shovel cultivator; 16 percent a two-horse, six-shovel cultivator; and 16 percent a one-horse, five-shovel cultivator; for an average of 3 cultivations. In Pennsylvania 68 percent used a one-horse, five-shovel; 36 percent, a two-horse, six-shovel; 7 percent a two-horse, eight-shovel; 7 percent a one-horse, two-shovel; and 7 percent the two-horse, one-row with scraper cultivator; for an average of 4.2 cultivations. In Wisconsin, 92 percent of the farmers used the two-horse, six-shovel cultivator; 15 percent, the one-horse, five-shovel; 8 percent, the two-horse, eight-shovel; and 4 percent, the two-horse, ten-shovel, spring tooth cultivator; for an average of 3.4 cultivations.

These data clearly indicate diverse usage of tillage implements in these three sections. Part of this diversity is due to the relative importance of corn as compared with other crops and to the use of implements especially adapted to the tillage of other crops; part to the availability of the machine in question; and part to custom. The Wisconsin farmers used implements similar to those employed in the main corn belt, while in Connecticut potato and tobacco implements are used on corn fields.

HARVESTING MACHINERY

Harvesting machinery constitutes the final group of implements which exert a considerable influence upon soil structure. The potato digger moves considerable soil and does effective tillage work; the root plow used in harvesting beets, carrots and turnips is quite a factor; while the bean puller is not particularly serviceable. The service

rendered by the potato digger and the root plow amounts essentially to that of an extra plowing, so thoroughly do they loosen and aerate the soil.

TILLAGE TOOLS WHICH COMPACT THE SOIL

The roller is the best known implement of this class. The results secured from the use of a roller are sometimes disappointing. Bonebright (3) states the case as follows: "It was known that a roller would crush clods and in some cases it might help seeds to germinate. Its detrimental effects when unwisely used were scarcely understood at all. For this reason its use was often a source of loss rather than gain to the farmer * * * The compacting effect of the roller is often completely overlooked by the farmer who wishes to crush a few unsightly clods. The compacted soil may oftentimes do more harm than the clods could possibly do.

Owing to the fact that the particles of earth are brought into closer proximity to each other, capillary action goes on more rapidly in the compacted soil. The moisture in the sub-surface soil is brought to the surface more rapidly and, consequently, the seeds in the dry surface layers—if these layers chance to be dry—receive more moisture than they would if the ground had been unrolled. This is one of the best results which may be secured by the use of the roller. However, the moisture rises rapidly to the surface and is evaporated by the passing currents of air. If one wishes to bring the moisture to within a short distance of the surface of the ground and hold it there, all that is necessary is to roll the field with a properly weighted roller and then harrow the ground with a smoothing harrow. This process forms a dust mulch upon the surface and thus prevents rapid loss of moisture by evaporation."

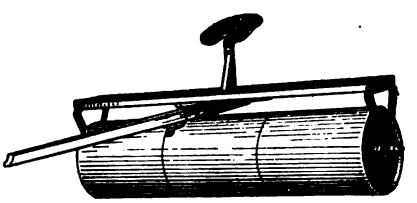

FIG. 18. A smooth land roller, used in seedbed preparation and to compact light, porous soils following plowing.

Eastern farmers, as a rule, if they use the roller at all, employ the smooth form made of wood or cast iron. The dangers are most serious when this type is used. The corrugated rollers are more popular in the West and now are being introduced in the East. The surface corrugations catch, crush and split the clods, while the smooth roller frequently merely presses them into the soil. The corrugated roller leaves the surface in a crumbled condition less favorable to loss of water by

evaporation than from the smooth surface left by the plain roller. The most widely used corrugated roller is the disc roller, made up of cast iron wheels with "V" rims set close together. These are durable and efficient. Other forms have longitudinal pipes or rods on the rim of the roller—which are apt to be bent out of shape with use—while still others have flat wheels with irregular projections from the side of the rim—which tend to break off in stony soil. A roller should be from twenty to twenty-four inches in diameter, and should weigh about 100 pounds per foot of width.

FIG. 19. A corrugated or disc roller or pulverizer, used in seedbed preparation.

The plank clod crusher or drag is a very efficient tool for its special purpose and in cases where the soil should not be compacted as much as by the use of a roller. It is usually a homemade tool consisting of three or more planks so spiked together in overlapping fashion as to catch and crush clods as the tool passes over them. It is perhaps a better pulverizer than the roller since its sliding action seems more effective than the rolling motion. And it does not compact the surface as greatly, and compaction, it should be remembered, may be a benefit or an injury according to circumstances. It does not adapt itself to surface irregularities and one rarely goes joy riding on a plank drag.

The Meeker harrow also splits clods into finer masses. It consists of numerous thin, straight steel discs set on axles with the discs on one axle half way between those on the other and so close to it that the clods have no chance to slip around them. The action of the Meeker is almost entirely one of cutting rather than crushing. It is not widely used.

The Acme harrow (fig. 6, page 73) is an efficient pulverizer. Its twisted blades are set so that they combine the clod crushing of the plank drag with some of the cutting action of the Meeker harrow. It leaves the soil in good condition for a seedbed.

TILLAGE REQUIREMENTS OF VARIOUS CROPS

The general principles of tillage apply to all crops; but certain crops do best with special soil conditions. For example, potatoes require a deep mellow seedbed. This can be secured by spring plowing to loosen the soil just previous to planting, followed by deep and thorough preparation with disc and spike tooth harrows. Obviously the roller should be kept off the field, for a loose and not a compact seedbed is needed. Corn is less fussy than is the potato crop in this respect; yet it needs a deep and well prepared soil. The use of an open wheel corn planter affords all the compaction that is necessary to aid in germination and at the same time will leave the soil loose enough so that the plants can come to the surface. (In this connection see the discussion of corn cultivation in bulletin 189, pages 341-346). Oats, barley and wheat require a finely prepared surface soil, but do best if the soil at three to six inches in depth is quite compact. The knowledge of this requirement has made it possible to economize in power and time required for preparing some soils for these crops. Where oats follow corn or potatoes, it is quite possible to use the disc harrow and prepare a satisfactory seedbed without the use of the plow. Plowing will usually pay where there is an abundance of vegetation to turn under, or on extremely heavy soils that are too compact even for oats till loosened. (In this connection see the discussion of oat planting and cultivation in bulletin 197, pages 56 to 60).

In the winter wheat section of the northeastern United States many farmers instead of plowing use a disc harrow or a sulky cultivator harrow to dig up the surface three to four inches. They save the extra labor and actually secure larger yields than when the soil is over loosened. This practice is confined to the preparation of bean and early potato fields for wheat. It is not so successful where grain stubble is to be followed by wheat.

Successful tillage operations can be accomplished without the use of all the implements briefly discussed in this bulletin. A plow, harrow and one-horse cultivator represent the absolute minimum. A sod plow and a stubble plow for different soil conditions, a disc and a spike tooth harrow, one-horse and a two-horse cultivator, would represent a medium outfit. Double disc harrow, roller, weeder, Acme harrow, a deep tilling machine, and several cultivators are implements that are highly desirable. The small farm cannot afford these because the investment becomes too heavy. Large sizes make for rapid tillage, so that one can take advantage of favorable moisture conditions and

prepare a seedbed with a minimum of labor. Here again the small field is handicapped. The use of new and improved tillage implements on medium to large fields and on level farms represents one of the handicaps which the hill farm always will have to contend with. It is best solved either by joining two or more hill farms into one, or by growing hay and pasture on the land too rough to work with ease.

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JULY, 1916 BULLETIN 199

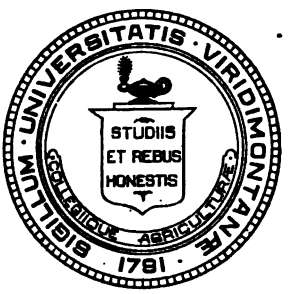
University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

TWENTY-NINTH ANNUAL REPORT

1915-1916



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University of Vermont and State Agricultural College

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BURLINGTON, VERMONT

TWENTY-NINTH ANNUAL REPORT

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☞Address all communications concerning station matters, not to individual officers, but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

ANNOUNCEMENT

The Vermont Agricultural Experiment Station is organized under an act of the General Assembly of 1886 and acts of Congress approved March 2, 1887, and March 16, 1906. Subsequent state legislation has placed upon the Station the duties pertaining to: (1) the inspection of commercial fertilizers; (2) the inspection of commercial feeding stuffs; (3) the inspection and certification of Babcock glassware and operatives; (4) the inspection of agricultural seed. Its financial support is derived from congressional funds; from state appropriations for report printing and for feeding stuffs and agricultural seed inspection; and from fees from commercial fertilizer manufacturers.

The Station is prepared:

1. To analyze fertilizers, feeding stuffs for domestic animals, seeds, milk and other dairy products, soils (for acidity only), and agricultural materials and products in general, when the results of such analyses are deemed to be of public benefit.

The Station is *not* prepared:

1. To identify fruits, grasses, weeds and other plants, fungus diseases, insect pests, etc., or to advise and assist by correspondence touching matters pertaining to agriculture, horticulture, plant or animal diseases, insect injuries, etc. The service of this character which the Station for nearly 25 years has gratuitously rendered is now performed by the Agricultural Extension Service of the College of Agriculture.

2. To identify or analyze minerals, drinking water, human food or drugs. Minerals should be sent to the State Geologist, Burlington. Waters, human foods, drugs and poison cases should be referred to the State Board of Health Laboratory, Burlington.

3. To test milk and cream regularly and in a wholesale way for any individual or company.

Instructions for taking samples of fertilizers, feedings stuffs, milks and creams, seeds, soils, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. The carriage charges on parcels sent by mail or express should be fully prepaid and they should bear the address of the shipper for purposes of identification.

FINANCIAL REPORTS FOR THE FISCAL YEAR ENDING

June 30, 1916

FOR THE HATCH AND ADAMS FUNDS

	Hatch	*Adams*
To receipts from the Treasurer of the United States, as per appropriation for fiscal year ending June 30, 1916, as per acts of Congress approved March 2, 1887, and March 16, 1906	$15,000 00	$15,000 00
By Salaries	$ 8,623 03	$ 9,709 39
" Labor	1,924 65	2,562 16
" Publications	296 44	.....
" Postage and stationery	280 33	48 81
" Freight and express	89 11	14 21
" Heat, light, water and power	813 42	.....
" Chemicals and laboratory supplies	203 24	343 26
" Seeds, plants and sundry supplies	254 63	202 20
" Fertilizers	222 36	1 88
" Feeding stuffs	877 87	1,440 09
" Library	38 60	14 24
" Tools, machinery and appliances	20 78	52 88
" Furniture and fixtures	21 23	26 09
" Scientific apparatus and specimens	76 91	201 56
" Live stock	459 10	4 40
" Traveling expenses	488 43	317 12
" Contingent expenses	20 00	.....
" Buildings and land	289 87	61 71
	$15,000 00	$15,000 00

FOR THE FERTILIZER CONTROL, FEEDING STUFFS INSPECTION, AGRICULTURAL SEED INSPECTION AND CREAMERY INSPECTION FUNDS

To license fees for 1916 received from fertilizer companies.		$3,095 00
To state appropriation for feeding stuffs		500 00
To state appropriation for agricultural seed inspection	$ 500 00	
To fees for agricultural seed analyses	43 50	
		$ 543 50
To balance on hand last report (creamery inspection)	$ 18 01	
To receipts from applicants for licenses	53 00	
To receipts for testing Babcock glassware	197 89	
		$ 268 90

	Fertilizer control	Feeding stuffs inspection	Agricultural seed inspection	Creamery inspection
By Salaries	$1,208 34	$ 282 69	$ 258 33	$ .....
" Labor	216 32	27 05	87 78	238 48
" Publications	28 72	.....	28 72	.....
" Postage and stationery	24 77	6 70	33 15	4 50
" Freight and express	19 04	6 57	0 26	3 61
" Heat, light, water and power	52 97	.....	.....	.....
" Chemicals and laboratory supplies	192 05	.....	.....	.....
" Sundries	19 50	.....	3 00	6 45
" Traveling expenses	772 42	176 99	118 58	.....
" Buildings and land.	4 26	.....	.....	.....
Unexpended balance	556 61	.....	13 68	15 86
	$3,095 00	$ 500 00	$ 543 50	$ 268 90

REPORT OF THE DIRECTOR

JOSEPH L. HILLS

The present report covers the work of the Station during the fiscal year July 1, 1915 to June 30, 1916.

PUBLICATIONS

Eight bulletins, one circular and the current annual report aggregating about 750 pages of printed matter, have been issued during the year, the bulletins in editions of 16,000 (save Nos. 193, 195 and 196, technical bulletins issued in smaller edition), the report in an edition of 1,000. A list of publications issued, other than the report, follows:

November.	No. 191.	The Red Rot of Conifers, by F. H. Abbott—20 pages.
December.	Circular 10.	Concerning the Use of Commercial Fertilizers in 1916, by J. L. Hills—16 pages.
February.	No. 192.	Agricultural Seed, by G. P. Burns—40 pages.
	No. 193.	Studies in Tolerance of New England Forest Trees; III. Discontinuous Light in Forests, by G. P. Burns 24 pages.
March.	No. 194.	The Trees of Vermont, by G. P. Burns and C. H. Otis—240 pages.
	No. 195.	Studies of the Values of Different Grades of Milk in Infant Feeding, by R. M. Washburn and C. H. Jones —144 pages.
April.	No. 196.	Some Studies of Bordeaux Mixture, by B. F. Lutman—80 pages.
May.	No. 197.	Commercial Feeding Stuffs, by J. L. Hills, C. H. Jones and G. F. Anderson.
		Concerning the Oat Crop, by J. L. Hills—72 pages.
June.	No. 198.	Commercial Fertilizers, by J. L. Hills, C. H. Jones and G. F. Anderson.
		Concerning Tillage, by R. T. Burdick—84 pages.

The more technical publications are issued in editions of small size, the more popular bulletins in larger editions. Only one set by number is issued, notice usually being given on the title page of the more popular issues of the existence and nature of technical numbers not generally distributed. The report consists of general business statements together with reprints of the bulletins of the year.

CHANGES IN THE STATION STAFF

A. A. Borland, M. S., Animal and Dairy Husbandman, resigned September 15 to return to his native state, Pennsylvania, to engage in extension work, and G. F. E. Story, B. S., of the Massachusetts Extension Service, a former University of Vermont student, was secured in his place. Messrs. C. G. Williamson and E. L. Baker, respectively Assistant Chemist and Computer, severed their station connections during the year. No successors were appointed.

THE USES OF THE SEVERAL STATION FUNDS

Hatch fund (Federal): "To conduct original researches or verify experiments"; the publication and distribution of the results of station work; administrative work.

Adams fund (Federal): "Only in paying the necessary expenses of conducting original research or experiments."

Neither of these funds can be used in indicating the application of research work save by bulletin publication or correspondence, but are employed simply in making the research which lies back of its application. The latter is now provided for in the Agricultural Extension Service. The Adams fund in particular is hedged about by restrictions and used strictly for research.

Fertilizer control fund (License fees for commercial fertilizers): Solely in the collection and analysis of samples of commercial fertilizers and the publication of the results of analysis, together with additional information bearing upon soils, fertilizers and soil management. The unused residues revert to the state treasury and have done so for several years. They now amount to a considerable sum.

Feeding stuffs inspection fund (State appropriation, $500): Solely in the collection and analysis of samples of commercial feeding stuffs and the publication of results of analyses, together with additional information bearing upon feeds and feeding.

Agricultural seed inspection fund (State appropriation, $500; fees): Solely in the collection and analysis of samples of agricultural seed and the publication of the results of analyses, together with additional information bearing upon seed and its use.

Creamery inspection fund (License fees, etc.): Solely in determining the ability of test operators and the accuracy of glassware.

Report printing fund (State appropriation, not to exceed $1,000): For printing the annual report.

HATCH AND ADAMS PROJECTS

The following Hatch fund projects have been in hand:

I, II, III, XII. Administration.

IV. Eccentric growth; tree temperature studies (Botany).

V. (1) Soil studies; (2) Work for other station departments; (3) Free analytical work in accordance with P. S. 352 (Chemistry).

VI. Forest reproduction; permanent plot work (Forestry).

VI. Hardwood factor studies (Forestry).

VIII. Quality and quantity studies with squash (Horticulture).

IX. Strawberry runner selection (Horticulture).

X. Cion selection (Horticulture).

XI. Cherry graftage (Horticulture).

XIII. Club-root of cabbage and allied plants (Plant pathology).

XIV. Effect of digestive fluids on spore viability (Plant pathology).

XV. Infectious bovine abortion (Veterinary science).

The following Adams fund projects have been in hand:

I. Forcing plants with carbon dioxid; begun in 1909. (Horticulture).

IV. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, related questions; begun in 1906. (Dairying; chemistry).

V. Effect of feeding different amounts of digestible protein to cows for a long period; begun in 1906. (Dairying; chemistry).

VI. Study of fundamental processes relative to the storage of sugars and other carbohydrates in wood and in the bark of the sugar maple, brown ash, birch, beech, oak, pine and apple; begun in 1909. (Chemistry; forestry).

VII. Maintenance rations for dairy cows, proportions of nutrients used; (a) maintenance, (b) in foetus construction, (c) in milk formation; begun in 1906. (Dairying).

VIII. Stimulating effect of bordeaux mixture on plants, especially the potato plant; begun in 1909. (Plant pathology).

IX. The effect of age and climatic conditions upon the efficiency of bordeaux mixture and other fungicides as shown by the inhibitory effect upon spore germination; begun in 1910. (Plant pathology).

X. The potato scab; a study of immunity of the advance of the disease during the growth of tubers, etc., the relation of the effects of various chemicals; etc.; begun in 1909. (Plant pathology).

XI. The tolerance of forest trees; begun in 1911. (Botany).

XII. The damping off of seedlings due to fusariums and other organisms; begun in 1908. (Plant pathology).

XIII. Plant breeding studies with *Violoceae* and *Rubus;* begun in 1913. (Botany).

XIV. Sterility of strawberries; begun in 1914 (Horticulture).

XV. Blood complement studies; begun in 1915. (Veterinary science).

THE FREE ANALYSIS PRIVILEGE

Section 352 P. S. requires the Station to make free analyses of agricultural materials for residents of Vermont. The statutes omit to make any appropriation to the Station for doing this work. The calls made upon the Station under this statute are rapidly increasing. There

were 798 such free analyses made in the fiscal year of 1911, during the fiscal year which closed a year ago and during the past fiscal year almost 2,500, a four fold increase within five years. It was said in last year's report that "this increase is due to many factors. The parcel post makes it easier and cheaper to send packages nowadays than formerly; the county agents have aroused popular interest and have informed the farmers as to the existence of the privilege; certain feed dealers thus use the Station in connection with a very shewd advertising scheme which serves to put money into their pockets; great interest is being aroused in connection with the use of lime on soils; and there are other reasons. The burden of this work is becoming heavy. It is a question whether the Station can carry on this work indefinitely if it continues to increase, without assessing its cost upon those who send the samples, as is generally done by the stations in other states which receive no state appropriation."

In view of this situation the Trustees in their forthcoming report to the next General Assembly have asked that this work be supported by direct appropriation.

Department Reports

The following concise statements indicate something of the scope of the work which has been in hand during the past fiscal year:

Animal Husbandry

The department has been concerned with the following projects:

1. *The feeding trials in which varying amounts of protein are fed* either continuously or alternately for long periods of time, beginning in 1906, and vigorously pushed throughout the year, were modified in 1914 so as to include a very low protein ration. The immense amount of data now in hand has been collated and bulletin publication during the coming year is confidently expected.

2. *The maintenance requirements of dairy cows* are being studied to determine the nutrients necessary for (a) body maintenance, (b) foetal development, (c) milk production, (d) foetal development and milk production. Representative cows in considerable numbers are being used and data are slowly accumulating.

3. *The metabolic requirements of dry cows* which alternately gain and lose in weight between wide limits are being studied and interesting data are being accumulated. The trial has been under way for some years and has been enlarged recently with a view of minimizing possible error due to personal equation.

4. *The nutritive values of milk in the feeding of the human young* has been under review for many years and a bulletin (No. 195) has just been issued. The trials were completed some years ago but the manuscript could not be prepared until recently. Further studies along these lines will be inaugurated, beginning August 1, 1916.

ADVANCED REGISTRY

The Station, acting in accordance with the rules adopted by the Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian and Jersey Breeders' Associations, exercises oversight and vouches for the accuracy of advanced registry records. This work is extra-legal in that it is not, as is all other work done by the Station, prescribed by state or by federal law. The Station acts for the breeders at their request. The work, being done for private individuals, is financed by them. Incidentally it has public relationships, in that anything which may be done to enhance the value of the dairy stock in a sense is work done in the interests of good dairying throughout Vermont.

The volume of this work is now large and it is well systematized.

Five years ago 16 breeders thus made use of the Station, whereas this year 102 Vermont breeders have secured advanced registry records. Less than 600 test-day records were made during the fiscal year of 1910-11, whereas more than 3,580 were made the past year.

A large part of the work is done in three southern counties, Windham, Windsor and Rutland, and almost all of it in these three together with Caledonia, Franklin, Lamoille and Washington counties. There seems to be some relationship existing between the activity of the county fairs and advanced registry work. There is a live fair organization in each of these seven counties, whereas in but one of the counties in which little or advanced registry work has been done is there a large fair.

The following statement sets forth the work done in 1915-16:

Ayrshire. Eight breeders have had 116 cows on semi-official yearly tests, with a total of 496 tests for 992 days.

Brown Swiss. One breeder has had 5 cows on test with a total of 11 tests for 22 days.

Guernsey. Four breeders have had 25 cows on semi-official tests, with a total of 139 tests for 276 days.

Holstein-Friesian. Sixty-seven breeders have had 359 cows tested for 2,780 days. Twenty-two of these cows were on semi-official yearly test with a total of 73 tests for 147 days and were tested for 14 days, three for 20 days, one for 25 days, four for 30 and two for 60 days.

Jersey. Twenty-two breeders have had 277 cows on test for a total of 1,544 tests for 3,088 days, all being semi-official yearly tests.

FINANCIAL STATEMENT ADVANCED REGISTRY JULY 1, 1915—JUNE 30, 1916.

RECEIPTS

Cash on hand July 1, 1915	$ 240	80
Official test fees	5,521	55
	$ 5,762	35

DISBURSEMENTS

Salaries	$ 710	04
Labor	4,007	00
Postage and stationery, telephone and telegraph	132	37
Freight and express	14	08
Chemicals and laboratory supplies	42	61
Sundry supplies	34	15
Furniture and fixtures	8	05
Travel (supervisors)	483	96
Travel (official)	57	68
	$ 5,489	94

ASSETS.

Receipts (as stated above)	$ 5,762	35
Due from breeders (Mar., Apr., May, June)	381	60
	$ 6,143	95

LIABILITIES

Disbursements (as stated above)	$ 5,489	94
Due supervisors	308	84
	$ 5,798	78
Cash on hand June 30, 1916	$ 272	41
Excess amount due from breeders over amount due supervisors	72	76
	$ 345	17

BOTANY

The work in this department has been prosecuted along five lines:

1. *Forest botany tolerance.* The departmental staff has continued the study of tolerance of New England forest trees during the year, devoting its time largely to a study of the conditions best suited to the development of white pine and other seedlings. The physical conditions in the woods under lath shades and under cheese cloth shades were studied, especially during the summer months in continuation of the work of previous years. The third bulletin in this series, No. 193, entitled "Discontinuous Light in Forests" has been published during the year.

2. *Forest botany eccentric growth.* The experimental work carried on to determine the cause of eccentric growth in trees was continued through the year, substituting small white pine and spruce grown in pots in the greenhouse for the larger trees growing in the

open. This change in the method of attacking this problem has been very profitable and significant results have been secured.

3. *Forest reproduction.* The field work on the plots which were cleared and on the adjacent control plots—as described in former reports—has been continued and aceurate records made of the changes observed. This work includes many types of forests in Vermont and is carried on in cooperation with the forester.

4. *The storage of starch.* The department is cooperating with the chemical department in the study of starch storage in trees. Many samples have been collected and preserved for future study.

5. *Plant breeding.* Considerable time has been devoted during the past year to the study of sterility among the Vermont forms of blackberries. The almost complete collection of Vermont forms of blackberries which are now growing in the station garden has been utilized. Several methods were employed. It appears that the amount of sterility varies greatly for the different species and hybrids. The significance of this variation in the amount of sterility as indicating the origin of these many forms is being studied. The effect of external factors on the growth and development of the different species of blackberries were studied from plants grown under controlled greenhouse conditions. The F. generation seedlings of the crosses made during the previous year and the seedlings of the natural hybrids were studied in reference to Mendelian characters.

CHEMISTRY

The work for the past year is covered in a general way by the analyses of licensed commercial fertilizers (bulletin 198); commercial feeding stuffs (bulletin 197); analytical work connected with the feeding trials with dairy cows, including roughages, concentrates and milk; and with more than 2,300 miscellaneous analyses of agricultural materials sent in by residents of the State.

1. *Feeding value of milk of different grades in infant feeding.* An extended investigation carried on in connection with the animal husbandry department designed to show the effect on body composition of young pigs resulting from the feeding of milk of different grades measured primarily by their fat content, has been completed and the results have been set forth in bulletin 195 entitled "Studies of the Values of Different Grades of Milk in Infant Feeding."

2. *The availability of the organic nitrogen in commercial fertilizers* has been studied as usual. Brands that show inferiority in this

respect have been studied, the organic portions separated from the inorganic and separately examined, and the original analyses confirmed. Cooperative work on nitrogen was also done for the Association of Official Agricultural Chemists.

3. *Soil studies.* Hundreds of samples from all sections of the State have been examined for lime requirement and organic matter content. The lime requirement was determined by the calcium acetate method, devised at this Station. Most of the samples tested are well supplied with organic matter, a very desirable condition. It seems quite certain that as a rule Vermont soils are quite acid and that the use of lime should be encouraged, particularly when clover and alfalfa are to be grown. While no opportunity has been afforded us closely to follow up the recommendations made on the basis of the calcium acetate test as to the use of lime, yet evidence is at hand which indicates that most satisfactory results have been secured. It seems safe to assert that the method is a practicable one, capable in the hands of a non-expert, a county agent for example, of affording in a few minutes the desired information as to so-called soil acidity conditions. In this connection it may be said that more than a hundred samples of limestone, mostly from Vermont sources, have been examined with a view of determining their suitability for local grinding for agricultural purposes.

4. *Carbon dioxid trials, etc.* Analyses have been made of about one hundred samples of the crops grown by the horticultural department in its carbon dioxid trials, with a view of determining the differences in dry matter, ash, protein and carbohydrate storage.

5. *The carbohydrate contents of maple and other woods* has been studied as time has permitted.

A total of 4,491 samples has been analyzed as follows:

Milk (station herd)	696
Milk and cream (from private individuals)	1,128
Commercial fertilizers (official)	168
Commercial feeding stuffs (official)	429
Roughages and concentrates (in connection with protein trials)	717
Maple syrups (maple investigations)	36
Wood (carbohydrate storage problem)	20
Commercial feeding stuffs (private individuals)	242
Miscellaneous (from private individuals) including soils	932
Miscellaneous (horticultural and botanical departments)	123
	4,491

INSPECTION WORK

1. *Commercial fertilizers.* Fertilizer control work continues to be an important and popular phase of station endeavor. The writing, printing and distribution of the results of the yearly inspection as well as of the compiled matter dealing with sundry phases of soil manage-

ment is paid for with fertilizer control funds. In no way whatsoever, directly or indirectly, are the federal funds used for this purpose. One hundred and sixty-eight brands, the output of 18 companies, were analyzed and with a few exceptions were found to be as good as they were said to be.

2. *Commercial feeding stuffs.* The small appropriation for this work, less than that made in any other state, necessitates an inadequate control of this trade. Nearly 700 samples have been drawn and analyzed for protein only. The outcome was a very unsatisfactory one, a large number of feeds being seriously deficient. The Station is able to purvey much general information in its feeding stuff bulletins.

3. *Creamery glassware and operators.* The volume of this line of work has been fairly uniform. Several thousand pieces of Babcock glassware, mostly cream bottles, were tested. The proportion of inaccurate glassware is quite small. A few would-be licensees were unable to pass an adequate examination and licenses were refused.

4. *Agricultural seed.* About 350 samples were collected in 1915 and nearly 500 in 1916. These have been tested, the results appearing in bulletins 192 (1915) and 200 (1916). Guaranties were omitted on one-seventh of the 1915 sales; were not made good in fact in one-twentieth of the samples; and 14 lots of timothy and red top were found to be ergotized.

FORESTRY

The experimental work for the past year has been along two lines:

1. *Permanent sample plot work.* These sample plots have been located in the University woodlot at Burlington, and on the state forests at Plainfield, West Rutland, Proctorsville and Townshend. In each case one or more experimental plots have been established and the check plots to accompany same. The plots are 100 feet square with isolation strips surrounding them. Each tree has been carefully located, the crown mapped in and the circumference measured. On each of the larger plots two or three sub-plots, ten feet square each, have been carefully mapped in order to study reproduction. Each season these sub-plots are carefully resurveyed and the number of seedlings of every kind of plant which comes into the plot tabulated. In this way we shall be able to formulate some very definite information as to what takes place under different conditions of light, moisture, etc. It is understood that this study is of a permanent nature and that the longer the experiment is continued the more satisfactory

will be the results. It may be possible, however, during the coming winter, to issue a preliminary statement of this work.

2. *Hardwood study.* The object of this study is to determine a more efficient and accurate method of estimating old growth hardwoods, especially in culled stands. It has been found that all available volume tables give very unsatisfactory results. The study is following the lines which have been worked out by Scheffel of Germany and Jonson of Sweden. The result will be either volume tables classified not only in height diameter classes, but also form classes, or else mathematical formulas which will enable the estimator to make local volume tables for any particular stand which he may be estimating. Very careful volume measurements are being made of hardwood timber wherever cutting is being done. The volumes, form factors, and form quotients of all of these trees are carefully computed. If possible, mathematical relationship between form factor, form quotient and volume will be determined. If the mathematical law cannot be discovered, these different factors will be arranged in tables.

HORTICULTURE

The work of the horticultural department of the past year has been devoted to a further prosecution of the following projects:

1. *Forcing plants with carbon dioxid.* The problem was that of determining the effect of the artificial application of this gas to various horticultural plants. Especial attention this past year has been given to the determination of optimum applications, computations on chemical modifications of treated plants, and preparation of manuscript for publication.

2. *Sterility of strawberries.* Many varieties of strawberries are self-sterile because of their unisexuality. The project called for a study of the causes and remedies of this sexual imperfection. Breeding experiments have started to study the behavior of sexes in crossed and uncrossed progeny. The record generation plants have been secured, and the third generations crosses are being made. Nutrition experiments are also under way with a view of studying the effect of varied feeding upon sex characteristics.

3. *Cion selection.* The study of the effect if any of the selection of cions from parent trees of superior or inferior fruiting habits which was started several years ago has been continued during the past year. Many of the cions are coming to a bearing age and their ca-

pabilities are being noted. Increasingly as the years go on this project should bear fruit, both figuratively and literally.

4. *Quality and quantity in Hubbard squash.* A further study has been made of the internal factors that govern quantity and quality in squash. Seed selection work has been continued, using seed from high and low yielding plants of both crossed and uncrossed parents, also from intercrossed specimens. Selections have been made on the basis of quality, particularly with reference to mealiness, wetness and coarseness of the flesh. The ultimate effect of continued self-fertilization is also being determined.

5. *Strawberry runner selection.* This project involves the question of improving the yields of strawberry plants by some method of stolon selection on the basis of parental yields. Earliness or lateness of formation; from one year or two year old plants; high and low yields; abundance and scarcity of stolons formed, are the contrasting factors. A considerable number of plants are under experiment.

PLANT PATHOLOGY

The plant pathology projects which have been in hand include:

1. *Potato scab.* The study of potato scab has been continued along practically the same lines as in the previous year. A detailed study of the structure of the skin of resistant and susceptible tubers has been made with interesting results.

2. *Effect of bordeaux on fungus spores and on sprayed plants.* A publication on this project has just been issued (bulletin 196). The favorable effect obtained from the use of bordeaux on potato plants seems to lie to a larger extent than has been heretofore appreciated in the prevention of tip-burn and all experimental and observational work on this project has dealt with this phase in the life history of the potato in this climate.

3. *The fusarium wilt of peas and asters.* The resignation of the associate plant pathologist, effective in June, 1915, has prevented much continuous work on this project during the past year; but it is expected that the data which have been secured on the conditions of infection will be made available for publication in the near future.

4. *Club-root of cabbage and allied plants.* This project, having been placed in the charge of the former associate plant pathologist, could not be pushed as vigorously as in previous seasons. However, much additional data as to disease resistance of several varieties of cabbage and other plants and as to the effects of soil treatment are in

hand. It is hoped that a final publication dealing with this project can be made during the present year.

VETERINARY SCIENCE

The work of the department for the past year has been confined to the furtherance of the following projects:

1. *The treatment of infectious abortion.* During the first half of the year samples of blood from over 500 cows were subjected to the complement fixation test and over 100 additional reacting cows were treated with methylene blue and cresol. During the last six months owing to war conditions methylene blue could not be obtained in sufficient quantities to enable the completion of this investigation. Methylene blue is made in Germany and now out of the market. It is quoted at $80 a pound, whereas it formally cost but $1.50 a pound.

The period of treatment has been reduced to three weeks, and in all herds where reacting animals have been left untreated to serve as control, there has been a pronounced showing in favor of the treatment. The cows in the treated class which aborted did so during or within two weeks of treatment or not until about three months had elapsed. The abortions which occurred during or within two weeks of treatment are believed to have represented cases which were too far advanced to be controlled and the occasional occurrence of abortion three months or more after treatment is attributable to reinfection.

2. *Improvements in the technique of the complement fixation test.* Improvements in the development and handling of the factors involved in the complement test which have been worked out by this department have been on trial during the past year. A manuscript is now in process of preparation setting forth the nature of the improvement and the results attained by its use.

3. *Control of blood complement.* Breeding experiments have been conducted throughout the year with guinea pigs in which selective mating with reference to complement titration has been practiced. Over 1,300 offspring were produced, the blood of which has been carefully titrated to determine the complement content. Very interesting results have been obtained, but larger numbers of animals will be required to clear up some details of the investigation.

SEPTEMBER, 1916 BULLETIN 200

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

AGRICULTURAL SEED

CONCERNING WEEDS AND WEED SEEDS

by G. P. BURNS and A. K. PEITERSEN

BURLINGTON:
FREE PRESS PRINTING CO.,
1916.

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☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications concerning station matters, not to individual officers, but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

BULLETIN 200: AGRICULTURAL SEED CONCERNING WEEDS AND WEED SEEDS

By George P. Burns and A. K. Peitersen

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I. SUMMARY

Samples of 473 lots of agricultural seed were drawn in May from local dealers' stocks and tested for purity and viability (germination). More than one-fifth of the lots were not guaranteed as required by law. Approximately four percent of the lots which were guaranteed were found to be seriously deficient in purity as compared with the promises made by their purveyors. The location of the deficiencies and the failures to guarantee may be readily noted by reference to the tables on pages 19 to 50, arranged either by kinds of seed (e. g. millet, oats, timothy, pages 19 to 37) or by names of wholesalers (e. g. Abbott Grocery Co., E. W. Bailey & Co., Barber and Bennett, pages 38 to 50).

There is abundant evidence at hand indicating that the seed trade is not as yet standardized and that it has not adjusted itself to the conditions brought about by the inauguration of inspection activities; and it is quite clear that in some respects the present law is not thoroughly adequate.

The reasons why a weed becomes a weed and how it can be effectually combatted are set forth on pages 60 to 62; and to the end that buyers may become familiar with the appearance of the weed seed most commonly found in our agricultural seed, 54 illustrations with explanations are shown in the last 15 pages.

II. INTRODUCTION

Acting under the authority conferred upon the Station by No. 184 of the Acts of 1912, its sampling agents visited 57 Vermont towns and villages and gathered during May, 1916, 473 samples of agricultural seed offered for sale in the open markets by local dealers, as follows:

Alfalfa 17	Redtop 11	Orchard grass 4
Barley 17	Timothy 69	Peas, field 6
Clover, alsike 50	Miscellaneous 45	Rape 1
Clover, red 69	Buckwheat 6	Rye 8
Corn 124	Clover, white 3	Sunflower 1
Millet 46	Italian rye-grass.... 1	Sweet clover 4
Oats 25	Kentucky bluegrass. 4	Wheat 7

These official samples were drawn in the manner prescribed by the rules of the Association of Official Seed Analysts. Purity tests were made by the weight method, a definite amount of seed being taken, its weight determined, pure seed, weed seed and inert matter or dirt separated, and the weight of each determined. The germination tests were made with Brown and Duval germinators, according to the method employed by the Federal Department of Agriculture.

The results obtained are presented in the following pages in tabular form. In the tables on pages 19 to 37 the data are arranged alphabetically under the names of the various kinds of agricultural seed. The trade or brand names, the names and addresses of retailers and wholesalers, the guaranteed and actual purity percentages, the percentage of viable seed (i. e., germination) and the approximate number of weed seeds in a pound are displayed. The presence of ergoted grain is shown in connection with the redtop tables. The same data are rearranged alphabetically by wholesalers' names in the table on pages 38 to 50. This arrangement facilitates reference by purchasers of seed. For example, a farmer who contemplates buying timothy seed wholesaled by the Brown Seed Company of Brownsville, Texas, and sold by the Smith Company of Smithville, Vermont, and desires as a guide to his purchase to know how well as a matter of fact the Brown Seed Company had lived up to its promise as to the grade of its timothy sales during the previous year, can turn directly to the data, instead of having to dig it out of the 69 analyses listed in the timothy table on pages 33 to 35. Furthermore, he can see at a glance the situation as to promise and performance of all their offerings during the preceding year as judged by station sampling and analyses. This system of alphabetical arrangement long has obtained in connection with the presentation of the analytical results in the fertilizer bulletins and this

year was put into operation likewise in connection with the feeding stuffs bulletin.

Ninety-eight samples of seed forwarded by individuals for free analysis have been tested during the year and 87 samples of seed have been sent in for analysis by dealers for the purpose of establishing guaranties. The fees assessed in accordance with state law for analyzing this latter class of seed have been turned into the State Treasury. Since the Station cannot vouch for the authenticity of these samples, the data secured thereon are not included in the tabular statements.

III. THE STATE AGRICULTURAL SEED LAW

The general assembly of 1912 passed an agricultural seed law (No. 184 of the Acts of 1912). It went into effect July 1, 1913, and became effective for the seed trade of 1914. The full text of this law appears in bulletin 183, which will be sent without charge to any address on application.

The following synopsis, setting forth in brief form and direct language the duties of the three parties in interest, namely, the wholesale seed house or purveyor, the local dealer, and the Station, should be helpful to all concerned. The farmer, that is to say the ultimate consumer, although not specifically mentioned in the law has moral if not legal duties in this connection, as indicated on page 7.

SYNOPSIS OF THE AGRICULTURAL SEED LAW

THE WHOLESALER'S DUTIES

This enactment requires:

1. *That agricultural seed*—the common grasses, clovers and cereals—*shall be truly named and guaranteed as to its purity* and freedom from foreign matter (weed seed, chaff, dirt, etc.) and seed other than the kind sold, provided such are distinguishable by their appearance.

2. *That agricultural seed shall be deemed to be "adulterated" if it contains more than one ergotized seed to the ounce* or more than one seed of corn cockle and a few other weeds specified by name, unless their presence and amount are declared on the package.

3. *That agricultural seed shall be deemed to be "adulterated" if its purity is substantially less than the statements made in its behalf would indicate.*

4. *That agricultural seed shall be deemed to be "misbranded" if it* is labeled in a false or misleading manner or *is not guaranteed.*

THE LOCAL SEED DEALER'S DUTIES

This enactment requires:

1. *That seed dealers see to it that "every lot or parcel of agricultural seed of five pounds or over sold,* offered or exposed for sale" *shall be truly named* as to its contents *and guaranteed* in writing or in print *as to its purity* and freedom from foreign matter (weed seeds, chaff, dirt, etc.) or seeds other than the kind sold, provided such are distinguishable by their appearance.

2. *That seed dealers see to it that they sell no seed which is adulterated or misbranded* within the meaning of the law (see 2, 3 and 4, above). Local dealers who feel that they cannot know some of the facts as to adulteration may, if they will, protect themselves by securing written statements from the wholesalers from whom they buy, as provided by section 6 of the act.

THE STATION'S DUTIES

This enactment requires:

1. *That the Station test, at specified fees, seed samples submitted for test of purity,* using the funds thus received for the purposes of the act.

2. *That the Station sample agricultural seed* as sold in the open market, *analyse* the samples thus taken, *compare the results* attained *with the guaranties,* and *publish information in full* as to their "character, value and use."

3. *That the Station notify wholesalers and retailers of violation of the law, hold hearings and notify states' attorneys of the results of such hearings,* with a view to prosecution "if in (the) judgment (of the state's attorney) the circumstances of the case warrant such action."

THE FARMER'S DUTIES

This enactment requires:

1. That the farmer do nothing whatsoever. He may buy the foulest seed that ever was harvested, if he wants to do so; and the law neither forbids his doing so nor shields him from his folly.

Common sense, however, requires:

1. That the farmer, when buying seed, take advantage of the protection afforded by the law.

2. That he note and be guided by the purity statement on the package.

3. That he note and be guided by the weed seed statement on the package.

4. That he insist on a guaranty in case a dealer attempts to sell him seed without the statement required by law.

5. That he study the annual seed inspection bulletins and compare wholesalers' promises and performances.

6. That he buys the better grades, which usually are likely to be the least costly not only in pure seed purchased but in the exclusion of weed seeds.

CONCERNING HIGH AND LOW GRADE SEED

This latter suggestion seems worth elaborating. The farmer who is buying seed should realize that a 100 percent purity statement on a seed package means "pure" seed, and that a 73 percent purity statement on a seed bag means that 27 percent of what he buys consists of weed seeds, dirt and other foreign material. He should try to grasp the idea that purchased dirt means lost money, lost not for one year only, which is bad enough; but that buying weeds at the price of good seed means not only lost money for one year but lost money at interest, at many times the legal rate, compounding at a usurious rate for long years to come in the shape of millions of weeds, a yearly loss which is quite equal probably to the taxes on the land they occupy. To pay taxes on land which grows mostly weeds, which were bought and paid for as timothy or clover or redtop, seems like adding insult to injury. Yet listers are inexorable and seed dealers offer cheap—but really costly—seed, full of weed seeds; for some farmers demand it.

The law protects the buyer who exercises care in purchase. In a general way he can form a shrewd estimate of the amount of weed seed in a given lot of seed by even a cursory survey of the label which the law requires each seller to affix to his offerings. The following excerpt from the 1916 data of Vermont sales accurately displays the general relation existing between a high purity guaranty and a low weed seed content on the one hand and a relatively low purity guaranty and a high weed seed content on the other hand.

HIGH GRADE AND LOWER GRADES COMPARED

Seed	Guaranteed purity	Approximate weed seeds per pound
Alfalfa	99.9	none
Alfalfa	98.8	1,300
Alsike clover	99.93	none
Alsike clover	89	22,500
Alsike clover	86.5	28,000
Redtop	97.1	18,000
Redtop	86.62	130,000
Timothy	99.97	none
Timothy	99.95	none
Timothy	94.16	47,800

He who buys a brand guaranteed in the high nineties usually is fairly safe, particularly if the station bulletin dealing with the previous year's trade indicates that the brand in question substantially maintained its guaranty statement. But the farmer who deliberately buys a seed carrying a low purity guaranty—and there are many such—cannot expect to get pure goods, any more than he who buys a suit of clothes at $4.79 can expect to wear all wool garments. However, it should be remembered that the guaranty statement does not always indicate thus by indirection the weed seed or other foreign matter content of a sample, for the reason that sometimes the guaranty is overstated.

The weed problem, like the poor, is always with us. If every farmer knew the seeds of our common grasses and clovers as well as he does those of oats, wheat and corn, there would be less weeds bought and paid for. It is not a difficult task to learn the appearance of these seeds. As for the weed seeds, it is only necessary to know that they are weed seeds. In most cases it matters but little what kind of weed seeds they are. The use of a common reading glass and the employment of a few minutes time may save the would-be buyer much future trouble. (In this connection see the illustrations and written matter on pages 60 to 80).

What percentage of purity may be expected? The following table is proof of the statement that dealers are able to furnish seed of high percentages of purity. They are glad to do so, they prefer to do so as a rule, for such seed gives better satisfaction than does a low grade brand, and a satisfied customer is one's best advertisement.

SAMPLES OF RELATIVELY HIGH QUALITY—VERMONT INSPECTION, 1916

	Guaranty of purity	Purity found
Alfalfa	99.5	99.95
Barley	99.4	99.28
Alsike clover	98	99.25
Red clover	99.5	99.6
Corn	99	100
Millet	99.5	99.82
Oats	99.78	99.92
Redtop	95	94.8
Timothy	99.95	99.97
Sweet clover	99	99.55
Wheat	99.5	99.96

A farmer who is buying seed may get some notion, indeed a pretty clear notion, of what sort is offered him by his dealer by observing the brand name and guaranty and then looking up the quality record of the brand as found on sale during the preceding year.

Unfortunately in the seed trade, as in feed and fertilizer trade, many wholesalers feel that they must meet the demands of those farmers who insist on buying only the lowest grades, on getting the most possible for a dollar regardless of quality. The law does not protect such a buyer against the consequences of his own unwisdom, the results of which may affect others as well as himself; for he who buys weedy seed endangers his more thrifty neighbors, whereas the man who buys a low grade fertilizer or a cheap feed damages only himself. Such being the case, it may be well to consider whether more drastic provisions might not be engrafted to advantage on the Vermont enactment, with a view of excluding the lower grades from our markets. Canadian laws prevent the sales of low grades; and they are shipped over the line for us to buy. We keep out undesirable human immigration, federal officers being stationed at Alburg, St. Albans, Richford, Newport and Beecher Falls for this purpose. Would it not be well to keep out undesirable plant immigrants, and, also, to make it less likely that our already large weed family be increased by further importation from our sister states?

IV. DISCUSSION OF THE RESULTS OF INSPECTION

A study of the tables on pages 19-37 and of the tables on pages 38 to 50 shows that many wholesalers furnish seed which are better than their guaranties and that their goods seldom fail to be as good as they are said to be. Speaking broadly, it appears that the guaranties of these houses can be taken without question at face value. It is a matter of regret that, if one is to judge by the results secured in the Vermont inspections of the past three years, this statement cannot be extended to

cover all the offerings of all wholesalers. The final remedy for this state of affairs does not lie in the application of the penal section of the law; as already has been set forth, the seed-buying public should inform itself by a study of the facts. Furthermore the situation as to guaranty maintenance is no better this year than heretofore as may be seen by the following comparisons:

Year	Number of samples	Number of lots guaranteed	Guaranties substantially made good	Guaranties more than 2 percent high of analyses	Percentage unguaranteed	Percentage seriously deficient
1914	234	191	187	4	18.3	2.1
1915	343	283	269	14	17.8	4.9
1916	466	366	352	14	21.6	3.8

The results of the laboratory tests show wide variations in the quality of the seed offered in Vermont markets during the spring of 1916. Some brands were quite weedy. A glance at the last column in the tables on pages 19 to 50, shows much variation in this respect. The law does not require the dealer to state the weed-seed content on his label, but the consumer doubtless would be glad to see the law so extended as to include this information, an extension which probably would be opposed strongly; but not by seed users.

The Federal Department of Agriculture has established certain standards of purity for agricultural seed. These are serviceable but they have no legal status. The Vermont law establishes no grades. The dealer may sell the foulest of seed without being in any way amenable to the law, provided that upon each lot of five or more pounds he sets forth clearly and accurately the nature and extent of its foulness. It is for the buyer to keep his eyes open. The law does not protect him if he is cheated in a horse trade, if he buys a spavined animal thinking it is sound. It does protect him in seed purchase, if he reads the statement on the package, so be it that they tell the truth; and he can find out if he will whether or not they are truthful.

VIOLATIONS OF THE LAW

The chief violations in 1916 were:

(1) Failure to furnish the guaranty required by law.

(2) Failure substantially to maintain guaranties.

(3) The undeclared sale of ergoted grains or of the presence of corn cockle.

1. *The omission of a guaranty seems inexcusable,* now that the law has been in force for three years; hence, beginning with 1916,

such errors of omission as came to the attention of the Station were dealt with, so far as this office is concerned, in accordance with the provisions of the law, as is set forth in the next three paragraphs. It is only just to say in this connection, however, that in several cases there seems reason to believe that guaranties were as a matter of fact furnished by the wholesalers in the form of tags which were either lost in transit or destroyed by the retailer, who failed to appreciate what he was doing and in what an unfavorable light he was placing both himself and the party from whom he bought his supplies. Failures to guaranty, therefore, are not always, perhaps not usually, to be charged against the wholsaler.

The seed law has been in force for three years. Two inspections have been made and the results published. Nearly a fifth of the lots of seed sampled in 1914 and one-sixth of those sampled in 1915 were found to be unguaranteed. It seemed as if the time had arrived when it were well to tighten up a trifle; accordingly a circular letter was sent to the retail trade throughout Vermont several weeks before the seed trade begun to be active. Walton's Vermont Register, 1916 edition, was used and every firm which seemed likely to be purveyors of agricultural seed was addressed. This letter set forth the duty of the retailer under the law and stated that retail dealers would be held responsible for failures to furnish guaranties. All wholesalers whose goods were found on sale in Vermont in 1914 and 1915 were similarly notified. The result was absolutely nil; indeed, if anything the effort was worse than useless, for the proportion of failure to declare a purity guaranty upon the package was greater than it was in 1914 and 1915, more than one-fifth of the lots being offered without guaranty. This situation is set forth in the table on the preceeding page.

Citations were issued for hearings on May 31 in accordance with Section 6 of the law. A considerable number of the parties who were called paid no attention to the notification, which of course was their privilege. Several came and acknowledged the correctness of the station's claim that they were selling unguaranteed seed. In the main their plea was that the matter had been "overlooked," although almost to a man they acknowledged having received the advance warning notice referred to in the preceding paragraph. It apparently had not made any serious impression on their minds. The situation as developed in several cases at these hearings is set forth in notes A to Y inclusive on pages 51 to 53.

The state's attorneys were notified in all cases as to the results of the hearings held on May 31. The phraseology of Section 6 of the law requires prosecution "if in his (the state's attorney's) judgment the circumstances of the case warrant such action." At the date of issuance of this bulletin, more than four months after these notifications were sent to the several state's attorneys, so far as the Station is informed, no action has been taken in any case looking towards prosecution.

2. *The divergencies between guaranteed purity and actual purity* found on analysis often were very small, and may be explained by sample variation or analytical variation; that is to say, the margin of error necessarily incident to the operations of sampling and analysis might well be considered to cover the divergency between promise and performance. No note should be taken of these cases; indeed the very terms of the law cover such occurrences and its phraseology was shaped designedly with this point in view when it was made to read—"provided that no penalty or liability shall be applicable to a seller of seeds in relation to the quality thereof, if the same is found to be substantially equivalent to the guaranty." In some cases, however, the discrepancy between guaranty and analysis seems too wide to be thus explained.

3. *The undeclared sale of ergoted grains* is in a measure excusable in view of the fact that, while a desirable feature of the law. for no one wants to grow ergoted grains, it is not prohibited by the laws of several states from some of which a considerable share of Vermont seed supplies are derived. Ergot is likely to occur only in timothy and redtop. Lots which have been found to be infested seriously in the past have been withdrawn from sale. The presence of ergot was declared on some lots.

The following tabular statement should prove of service to buyers of seed. It concisely sets forth the situation as regards compliance with the law by the several purveyors of seed, 473 samples of whose goods were taken in the spring of 1916, in so far as it relates to:

1. The presence or absence of the guaranty statement.
2. The failure to furnish substantially the proportion of pure seed which is guaranteed.
3. The presence of ergotized seed.

Name and address of wholesaler	Number of samples	Number guaranteed	Guaranties made good	Guaranties 2 % high	Ergot, etc., present
Abbott Grocery Co., Keene, N. H.	5	5	5	..	..
Adams, J. B., Randolph, Vt.	1	..	..	..	..
Amendt Milling Co., Monroe, Mich.	1	..	..	..	..
Badger Seed Co., ———	1	1	1	..	..
Bailey & Co., E. W., Montpelier, Vt.	28	7	7	..	..
Barber & Bennett, Albany, N. Y.	7	7	7	..	..
Barnes Co., O. J., Malone, N. Y.	1	..	..	..	..
Bradford Mills, Bradford, Vt.	1	1	1	..	..
Breck & Sons Corporation, Jos., Boston, Mass.	12	6	6	..	..
Burditt Bros., Rutland, Vt.	5	5	5	..	1
Champlain Seed Co., Burlington, Vt.	9	9	9	..	..
Clark, R. L., Barre, Vt.	1	1	1	..	..
Cobb & Co., W. F., Franklin, Mass.	1	1	1	..	..
Conklin & Son, E. W., Binghamton, N. Y.	26	26	26	..	..
Cox Co., C. M., Boston, Mass.	2	1	1	..	..
Craver-Dickinson Seed Co., Binghamton, N. Y.	6	5	5	..	..
Crosby & Co., E., Brattleboro, Vt.	2	2	2	..	..
Cross, Abbott Co., White River Junction, Vt.	5	3	3	..	..
Cunningham, W. C., St. Albans, Vt.	1	..	..	..	..
Davis, S. L., Putney, Vt.	1	1	1	..	..
Dibble, E. F., Honeoye Falls, N. Y.	7	5	5	..	..
Dwinell, D. B., East Calais, Vt.	1	..	..	..	..
Dickinson Co., A., Chicago, Ill.	51	50	50	..	1
Emerson, T. W., Boston, Mass.	5	3	3	..	..
Freeman, E. E., Waterbury Center, Vt.	1	1	1	..	..
Griswold & Mackinnon, St. Johnsbury, Vt.	2	2	2	..	..
Gunson & Co., L. P., Rochester, N. Y.	3	3	3	..	..
Holbrook Grocery Co., Keene, N. H.	40	38	37	1	4
Ide, E. T. & H. K., St. Johnsbury, Vt.	1	1	1	..	..
Johnson & Co., W. B., Essex Junction, Vt.	5	4	4	..	..
Jones, A. G. & C. W., Brandon, Vt.	1	1	..	1	..
Kempton, F. M., Barre, Vt.	2	1	1	..	..
LaFountain, Woolson Co., Windsor, Vt.	10	6	4	2	1
Landon & Co., W. C., Rutland, Vt.	1	1	..	1	..
Lapelle & Co., F. D., Swanton, Vt.	2	2	2	..	..
Lovell & Brown, Brattleboro, Vt.	1	1	1	..	..
Lyman, A. B., Excelsior, Minn.	2	..	..	..	..
Michigan Seed Co., Richford, Vt.	10	3	3	..	..
Middlebrook & Sons, J. O., Burlington, Vt.	11	10	9	1	..
Morehouse & Co., W. H., Toledo, Ohio	24	21	17	4	1
Nuhgesser-Dickinson Co., Hoboken, N. J.	6	3	3	..	..
Page Seed Co., Greene, N. Y.	4	1	1	..	..
Park & Pollard Co., Boston, Mass.	1	..	..	..	..
Pelkey, G. H., St. Albans, Vt.	1	..	..	..	..
Phelps & Co., O. G., Milton, Vt.	2	2	2	..	..
Rice Seed Co., J. B., Cambridge, N. Y.	14	7	7	..	..
Robbins & Cowles, Brattleboro, Vt.	3	..	..	..	..
Ross Bros. Co., Worcester, Mass.	1	..	..	..	..
St. Albans Grain Co., St. Albans, Vt.	1	..	..	..	..
Salzer Seed Co., J. A., LaCrosse, Wis.	2	..	..	..	..
Sherman, F. A., Albany, N. Y.	3	..	..	..	..
Skeels & Co., H. C., Swanton, Vt.	3	..	..	..	..
Slayton & Co., H. A., Morrisville, Vt.	3	3	3	..	..
Small & Co., W. H., Evansville, Ind.	12	8	7	1	..
Stanford Seed Co., Buffalo, N. Y.	71	66	65	1	..
Sweat-Comings Co., Richford, Vt.	2	2	1	1	..
Valley Grain Co., Brattleboro, Vt.	1	1	1	..	..
Varick Co., J. B., Manchester, N. H.	1	1	1	..	..
Whitney-Eckstein Seed Co., Buffalo, N. Y.	37	36	36	..	..
Williams, M. G., Putney, Vt.	2	1	..	1	1

An examination of the results given in this table shows:

1. That approximately four-fifths of the lots were guaranteed and one-fifth was unguaranteed.

2. That 96 percent of the guaranteed samples were substantially as pure as they were said to be.

3. That 9 lots contained ergot or corn cockle.

The wholesalers in some cases claim that the goods represented to be unguaranteed as a matter of fact were guaranteed. It is of course possible that in some cases the sampling agents overlooked the guaranties; but in view of the fact that the men who were employed in seed sampling have been engaged, some of them for several years, in sampling commercial fertilizers and feeding stuffs, commodities which are required to carry guaranties, more complicated ones than are those which are employed in the seed trade, and that without a single exception they recorded fertilizer and feeding stuff guaranties in their reports; and further, in view of the fact that in the initial years of the operation of the fertilizer and feeding stuff laws it was common for wholesalers through oversight to omit guaranties, a history which it is notorious is being repeated in connection with the inauguration of the new seed enactment, not only in Vermont but in other states; and finally, in view of the antagonistic attitude of many wholesalers, indeed of the wholesale trade in general, towards the enforcement of guaranty requirements; it seems safe to conclude that in most cases the sampling agent's report of "no guaranty statement" accurately represents the situation at the point at which the sample was drawn. It should be said on the other hand that it is not unlikely that in several cases the guaranties were as a matter of fact furnished by the wholesalers in the form of tags affixed to the bags and that the retailers removed them, not understanding what they were doing; a violation of the law in that goods thus exposed for sale by the retailers did not bear a guaranty statement. It may have been, however, that in some, perhaps in all, cases actual sales of five pounds or more were as a matter of fact properly guarantied. In fact, the nature of the seed trade is such that it is not as easy for the Station to assert dogmatically in a given case that the intent of the law has been defeated as it is in the case of a similar lapse in connection with the fertilizer or feeding stuff laws. The purchaser of either of these commodities buys it in the original package, in the condition in which it left the factory. The local dealer does not have to bother with the guaranty. It is furnished for him by the manufacturer and the ultimate consumer

secures it automatically when he makes his purchase. It is rare, however, that a farmer buying seed either receives the original package or sees it near enough at hand to note the printed guaranty it carries. Now the excuse for the existence of laws of this character is simply that he who buys may know what it is he is buying. A guaranty tag on the seed bag which is neither delivered to nor seen by the purchaser is of little or no use to him; hence the necessary, but—to the retailer—undeniably troublesome, requirement that name and purity statements be affixed to each purchase of five pounds or more. It is probably true that many, perhaps most, purchasers do not look at or care about the guaranty statement which is placed on the package. In the same way it is probably true that few housewives note whether or not their catsup bottles declare the use of benzoate of soda. Food manufacturers moved heaven and earth ten years ago to avoid the necessity of declaring the presence of this preservative in their goods, but without avail; and who shall say that because housewives do not always look at the fine print statement, therefore it is superfluous and unnecessary?. The writers do not believe the analogy is a strained one and they do believe that in no other way than that provided by the Vermont law can a seed buyer be adequately protected.

In some cases the authenticity of samples and the accuracy of analyses are questioned. The instructions given the sampling agents to take but one sample at a time, and to finish labelling one before beginning to take another sample, would seem reasonably well to safeguard the authenticity of the sample in so far as the Station is able to do so. The essential accuracy of the analyses of all samples listed as not substantially equalling the printed guaranty statement made in their behalf, or as containing ergoted seed, was determined by repeated trials. Sub-samples of these lots were submitted to the wholesalers on request, but no analyses as made and verified by our own analysts were quashed, the seller's results to the contrary notwithstanding. The Station affirms belief in the essential accuracy of all the analytical findings reported in this bulletin, assuming of course the authenticity of the original samples. However, it seems only right to give publicity to the protests of wholesalers as set forth in the notes on pages 51 to 53.

In the following cases divergence between promise and fulfillment seems excessive.

Holbrook Grocery Co., Keene, N. H.
Red clover; White Mountain .....Guaranteed 99.95 Found 96.6
A. G. & C. W. Jones, Brandon, Vt.
Timothy; unnamed .....Guaranteed 95 Found 92.37
LaFountain, Woolson Co., Windsor, Vt.
Alsike clover; unnamed .....Guaranteed 98.9 Found 93.5
Red clover; unnamed .....Guaranteed 97 Found 92.5
W. C. Landon & Co., Rutland, Vt.
Corn; Eureka .....Guaranteed 99.09 Found 96.86
J. O. Middlebrook & Sons, Burlington, Vt.
Winter rye; unnamed .....Guaranteed 98 Found 94.74
W. H. Morehouse & Co., Toledo, Ohio
Barley; Chevalier .....Guaranteed 99.5 Found 96.31
Corn; Eureka .....Guaranteed 98 Found 95.77
Corn; Minnesota Special .....Guaranteed 99 Found 96.25
Rye; Winter .....Guaranteed 99.25 Found 97.25
W. H. Small & Co., Evansville, Ind.
Red clover; Kaiser .....Guaranteed 98 Found 92
Stanford Seed Co., Inc., Buffalo, N. Y.
Corn; Longfellow Flint .....Guaranteed 95 Found 86.31*
Sweat-Comings Co., Richford, Vt.
Oats; unnamed .....Guaranteed 97.79 Found 95.15
M. G. Williams, Putney, Vt.
Alsike clover; unnamed .....Guaranteed 96.14 Found 77.5

*Worm eaten; perhaps not the fault of the wholesaler.

CONCERNING THE VIABILITY OF AGRICULTURAL SEED

The state law does not require a guaranty of viability (germination). Such a requirement is made in New Hampshire and perhaps one or two other states, but not in Vermont. The omission was intentional. Purity is a fixed, an unchanging characteristic; but viability varies from month to month, and sometimes rapidly lessens. Since a seed may not be sold promptly, its viability guaranty, correctly stated when the seed was fresh, may be much too high at the time when an official sample is drawn or the consumer makes his purchase. However, the Station tests the official samples as to their viabilities and publishes the results, as shown in the tables on pages 19-37.

Some interesting comparisons may be made. Thus, for example, the following maxima, minima and approximate averages are worth noting.

Kind of seed	Samples	Maxima	Minima	Average
Alfalfa	17	96	56.5	88
Barley	17	100	78.5	90
Clover, Alsike	50	97	43.5	85
Clover, Red	69	98	22	88
Corn	124	100	58.5	90
Millet	46	96.5	11.5	85
Oats	25	99	92	97.5
Redtop	11	88	38.5	65
Timothy	69	98	59	88
Buckwheat	6	99	95	97.5
Peas, field	6	94.5	92.5	93.5
Rye	8	97	53.5	85
Sweet clover	4	88	77.5	85
Wheat	7	97	68	90

The germination of all the oats, buckwheat and field peas was satisfactory. Five of 17 alfalfas; 2 of 17 barleys; 5 of 50 alsikes; 7 of 69 red clovers; 6 of 124 corns; 18 of 46 millets; 9 of 11 redtops; 11 of 69 timothies; 2 of 8 ryes; and 1 of 7 wheats; about one lot in five exclusive of corn; were not as viable seed as could be wished, the tests indicating a proportion of non-viable seed greater than one in five.

V. ANALYSES OF AGRICULTURAL SEED (BY KINDS)

NOTE:—The abbreviations of the wholesalers' names appearing in the following tables, pages 19 to 37, are explained as follows:

Abbott—Abbott Grocery Co., Keene, N. H.
Amendt—Amendt Milling Co., Monroe, Mich.
Badger—Badger Seed Co., ————.
Bailey—E. W. Bailey & Co., Montpelier, Vt.
Barb. & Ben.—Barber & Bennett, Albany, N. Y.
Barnes—O. J. Barnes Co., Malone, N. Y.
Bradford—Bradford Mills, Bradford, Vt.
Breck—Jos. Breck & Sons Corporation, Boston, Mass.
Burditt—Burditt Bros., Rutland, Vt.
Champlain—Champlain Seed Co., Burlington, Vt.
Clark—R. L. Clark, Barre, Vt.
Cobb—W. F. Cobb, Franklin, Mass.
Conklin—E. W. Conklin & Son Inc., Binghamton, N. Y.
Cox—Chas. M. Cox Co., Chamber of Commerce, Boston, Mass.
Crav.-Dick.—Craver-Dickinson Seed Co., Buffalo, N. Y.
Crosby—E. Crosby & Co., Brattleboro, Vt.
Cross, Abb.—Cross, Abbott Co., White River Junction, Vt.
Dibble—E. F. Dibble, Honeoye Falls, N. Y.
Dickinson—Albert Dickinson Co., Chicago, Ill.
Dwinell—D. B. Dwinell, East Calais, Vt.
Emerson—Thos. W. Emerson, Boston, Mass.
Gris.-Mack.—Griswold & Mackinnon, St. Johnsbury, Vt.
Gunson—L. P. Gunson & Co., Rochester, N. Y.
Holbrook—Holbrook Grocery Co., Keene, N. H.
Ide—E. T. & H. K. Ide, St. Johnsbury, Vt.
Johnson—W. B. Johnson & Co., Essex Junction, Vt.
Jones—A. G. & C. W. Jones, Whiting, Vt.
Lyman—A. B. Lyman, Excelsior, Minn.
Michigan—Michigan Seed Co., Richford, Vt.
Middlebrook—J. O. Middlebrook & Sons, Burlington, Vt.
Morehouse—W. H. Morehouse & Co., Toledo, O.
Nung.-Dick.—Nungesser-Dickinson Co., New York, N. Y.
Page—Page Seed Co., Greene, N. Y.
Park & Poll.—Park & Pollard Co., Boston, Mass.
Phelps—O. G. Phelps & Co., Milton, Vt.
Rice—J. B. Rice Seed Co., Cambridge, N. Y.
Ross—Ross Bros. Co., Worcester, Mass.
St. A. Grain—St. Albans Grain Co., St. Albans, Vt.
Salzer—John A. Salzer Seed Co., LaCrosse, Wis.
Sherman—F. A. Sherman Co., Albany, N. Y.
Slayton—H. A. Slayton & Co., Morrisville, Vt.
Small—W. H. Small & Co., Evansville, Ind.
Stanford—Stanford Seed Co., Buffalo, N. Y.
Sweat-Com.—Sweat-Comings Co., Richford, Vt.
Valley Gra.—Valley Grain Co., Brattleboro, Vt.
Varick—John B. Varick Co., Manchester, N. H.
Whit.-Eck.—Whitney-Eckstein Seed Co., Buffalo, N. Y.

ALFALFA

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
IXL	E. M. Bixby & Son, Poultney	Conklin	99.26	99.6	92	....
———	Vermont Marble Co., Proctor	Dibble	99.5	99.9	83.5	....
Ace	Burditt Bros., Rutland	Dickinson	99.3	98.8	90.5	900
Globe	F. H. Gillingham, Woodstock	Dickinson	99.45	99.5	92	....
Pine Tree	Valley Grain Co., Brattleboro	Dickinson	99.6	99.1	81	....
Pine Tree	J. O. Middlebrook & Sons, Burlington	Dickinson	99.5	99.55	84	90
Globe	S. Sherman & Son, Poultney	Crav.-Dick.	99.56	99.2	78	90
White Mountain	Lovell & Brown, Brattleboro	Holbrook	99.5	99.95	90	90
Grimm	L. L. Marsh, Enosburg Falls	Lyman	A	99.8	75.5	....
Grimm Hardy	Hatch Hardware Co., St. Albans	Lyman	A	99.64	78	....
Anchor	M. P. Perley & Co., Enosburg Falls	Morehouse	99	99.6	84	90
———	B. F. Whelden's Sons, Ludlow	Nung.-Dick.	97(V)	98.8	56.5	1255
Eclipse	Griswold & Mackinnon, St. Johnsbury	Small	98.5	99.65	94.5	....
Empire	Farmers' Exchange, Bradford	Stanford	99.5	99.8	95	90
Honor	S. P. Curtis & Son, Rutland	Stanford	99.25	99	77.5	450
Honor	W. F. Cunningham, St. Albans	Stanford	98.5	99.4	86	....
Eureka	J. H. Hewitt, South Royalton	Whit.-Eck.	99.5	99.2	94.5	90

BARLEY

———	R. L. Clark, Barre	Clark	85	98.38	97.5	85
Six Row Oderbrucker	E. T. Seabury Estate, Waterbury	Conklin	99.42	98.15	99.5	45
Six Row	Trumbull & Pease, White River Junction	Dickinson	99.5	97.9	100	15
Six Row	H. A. Slayton & Co., Morrisville	Dickinson	99.4	99.28	94	15
Six Row	A. H. McLeod Milling Co., St. Johnsbury	Dickinson	99	97.98	92.5	*40
Two Row	Burditt Bros., Rutland	Dickinson	98	97.96	84	....

*_Corn cockle._ The presence of this seed in proportions "in excess of one seed to the ounce . . . unless the name and maximum numbers of such seed to the ounce is placed on the label" constitutes adulteration (No. 184 of the Acts of 1912, Sec. 6).

BARLEY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Six Row	H. T. Brown, Ludlow	Holbrook	99.5	98.32	99	75
Chevalier	E. W. Bailey & Co., Montpelier	Morehouse	99.5	96.31	84	60
Six Row	M. P. Perley & Co., Enosburg Falls	Morehouse	98.9	97.83	99.5	75
Six Row	E. I. Benson, Woodstock	Stanford	90	97.86	78.5	15
———	W. H. Stearns, Johnson	Stanford	90	98.36	79	....
Six Row	M. A. Nelson, Montpelier	Whit.-Eck.	98	98.34	81	....
Two Row	E. E. Harris & Co., Morrisville	Whit.-Eck.	98	96.78	80	40
Recleaned	F. D. Lapelle & Co., Swanton	Local	97	97.9	83	15
———	J. O. Middlebrook & Sons, Burlington	Local	95	99.97	93.5	....
———	H. C. Skeels & Co., Swanton	Local	...	95.8	95.5	2380
Six Row	F. M. Kempton, Barre	?	98	99.28	100	54

ALSIKE CLOVER

Mastiff	W. R. Eames, Newfane	Abbott	92	95.5	86.5	8775
Badger	Story & Barkyoumb, St. Albans	Badger	99	97.5	86.5	2700
Ace	R. L. Clark, Barre	Bailey	B	96	90.5	2025
———	H. W. Myers & Son, Bennington	Barb.-Ben.	99	98.5	97	225
Kaiser	F. P. Edgerton, Wallingford	Burditt	92	96	88.5	3040
———	Richmond Lumber Co., Richmond	Conklin	96.25	97	89.5	3960
———	B. T. Henry, North Bennington	Conklin	96.25	97	84	4865
———	E. T. Seabury Estate, Waterbury	Conklin	96.25	96.5	87.5	7200
———	O. A. Cobb, Bridgewater Corners	Cross, Abb.	C	97	86	1125
Ace	S. A. Reed, Windsor	Dickinson	95	96.5	94	9115
Ace	H. O. Holt & Co., Richford	Dickinson	94	96.5	89	1385
Globe	W. B. Ladd, Enosburg Falls	Dickinson	98	97	92.5	1800
Kaiser	W. V. Phelps Co. Enosburg Falls	Dickinson	88	93	85.5	13210
Queen	Alexander Peltier, Highgate	Dickinson	88	89.5	81.5	38360
Queen	H. A. Slayton & Co., Morrisville	Dickinson	88	90	86	33420

ALSIKE CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
———	Field & Lawrence, Bellows Falls	Dickinson	93.34	97	86.5	1560
Ace	Burditt Bros., Ludlow	Crav.-Dick.	...	97.5	85	1350
———	B. W. Davis, Marshfield	Crav.-Dick.	88.25	94.5	83	8030
White Mountain	Geo. Shorey & Son, Lyndonville	Holbrook	98.5	98.9	92.5	675
White Mountain	Adams & Davis Co., Chester	Holbrook	98	99.25	97	2250
White Mountain	Berry & Jones, Montpelier	Holbrook	98.5	99.1	91.5	645
X	S. Sherman & Son, Poultney	Holbrook	70	84	56.5	19570
XX	Stearns Bros., Springfield	Holbrook	80	86.5	80.5	25670
XXX	Strong & Goddard, Hyde Park	Holbrook	90	95	86.5	19890
XXX	W. J. Boyce & Co., Woodstock	Holbrook	87	94.5	79	27000
80	H. E. Shaw, Stowe	Holbrook	80	89	76	21050
———	H. G. Folsom & Co., St. Albans	Johnson	96.31	98	89	1125
Anchor	H. H. Cushman, Rochester	Morehouse	D	98	86.5	450
Bell	M. P. Perley & Co., Enosburg Falls	Morehouse	97	99.3	91.5	....
———	P. D. Pike & Son, Stowe	Nung.-Dick.	E	98.5	92.5	220
———	Richmond Farmers' Corp., Richmond	Salzer	F*	98	87.5	675
Climax Superfine	Griswold & Mackinnon, St. Johnsbury	Small	97.2	98.2	93.5	675
Eclipse	Macdiarmid & Co., Newport	Small	...	97	94	215
Arc	W. C. Marsh, Sheldon	Stanford	96.68	98	80	....
Arc	L. S. Robie, Hardwick	Stanford	97.29	98.5	93.5	....
Fancy	J. E. Wagner, Milton	Stanford	95.84	98	93.5	....
Fancy	City Feed Co., St. Albans	Stanford	97	99	86.5	....
Fancy	H. T. Brown, Ludlow	Stanford	97.29	98.1	93.5	....
Queen	L. S. Robie, Hardwick	Stanford	87	94.5	84.5	16300
Reliable	H. O. Holt & Co., Richford	Stanford	95.75	99.15	93	215
Reliable	E. H. Mason, Randolph	Stanford	95.25	97.5	83	885

*Private purchase.

ALSIKE CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Reliable	Miles, MacMahon & Son, Stowe	Stanford	95.65	96	89.5	....
Eureka	F. D. Lapelle & Co., Swanton	Whit.-Eck.	98.5	98.75	95	....
Eureka	J. C. Eaton & Co., Lyndonville	Whit.-Eck.	98	98.7	86.5	1105
Eureka	J. W. Jones & Co., Burlington	Whit.-Eck.	99	99.8	96	....
Export Fancy	A. L. Wood & Son, Woodstock	Whit.-Eck.	98.5	98	93	....
Pan-American	F. D. Lapelle & Co., Swanton	Whit.-Eck.	97	97.8	84.5	1115
————	Robbins & Cowles, Brattleboro	?	....	90.86	92.5	3112
————	LaFountain, Woolson Co., Windsor	?	98.9	93.5	53.5	....
————	M. G. Williams, Putney	?	96.14	77.5	43.5	....

RED CLOVER

Old Home	W. R. Eames, Newfane	Abbott	96	98.62	68.5	2230
Ace	R. L. Clark, Barre	Bailey	B	98	92	2425
Ace	E. W. Bailey & Co., Montpelier	Bailey	99.5	99.6	86.5	270
————	A. H. Winslow, Bennington	Barb.-Ben.	99	99.2	95.5	540
————	A. A. Newcomb, Waterbury Center	Breck	G	97.9	84.5	3585
Ace	Burditt Bros., Ludlow	Burditt	98	99.2	95	715
A	M. P. Perley & Co., Enosburg Falls	Conklin	98.4	99	94.5	1620
Crown	E. T. Seabury Estate, Waterbury	Conklin	99.35	99.2	93.5	720
Crown Mammoth	E. G. & A. W. Norton, Vergennes	Conklin	99.35	99.2	94	450
Etna	H. P. Munson, Morrisville	Conklin	92.8	93.8	88.5	12330
Pilot Mammoth	E. M. Bixby & Son, Poultney	Conklin	98.5	98.53	93.5	1750
————	H. P. Munson, Morrisville	Conklin	98	97.78	95.5	2085
Very Best	B. S. Eastman, Groton	Cross, Abb.	93	97.2	93.5	4530
————	O. A. Cobb, Bridgewater Corners	Cross, Abb.	C	98	95.5	3415
————	Vermont Marble Co., Proctor	Dibble	99.5	98.6	92.5	630
————	Don Camp, South Barre	Dibble	99.5	98.8	95.5	1080

RED CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Ace Mammoth	Burditt Bros., Rutland	Dickinson	98	99.5	92.5	360
Ace	E. C. Dyke, Bristol	Dickinson	97	98.2	78.5	2580
Globe	F. H. Gillingham, Woodstock	Dickinson	99	98.8	85.5	1070
Kaiser	E. J. Davis, Chester Depot	Dickinson	97	97.4	83.5	4250
N. N. Y.	E. T. & H. K. Ide, St. Johnsbury	Dickinson	98	98	84.5	3605
Queen	W. C. Marsh, Sheldon	Dickinson	95	96.6	79.5	6590
Queen	W. C. Landon & Co., Rutland	Dickinson	96	97.1	87.5	6930
Queen	Alexander Peltier, Highgate	Dickinson	95	96.4	81.5	5400
———	Field & Lawrence, Bellows Falls	Dickinson	98.23	99.2	85	805
———	J. O. Middlebrook & Sons, Burlington	Dickinson	98	98.7	84	815
———	B. W. Davis, Marshfield	Dickinson	95.15	96.6	78.5	7290
Ace	H. E. Shaw, Stowe	Holbrook	98	98.4	91	2520
White Mountain	Geo. Shorey & Son, Lyndonville	Holbrook	99.5	99.2	95.5	720
White Mountain Extra Fancy	W. P. Cary, Wallingford	Holbrook	99.5	99.4	96	450
White Mountain Mammoth	W. J. Boyce & Co., Woodstock	Holbrook	99.55	96.6	22	2700
XX	Clark & Davidson, Groton	Holbrook	90	94.4	85.5	11430
XXX	N. W. Batchelder, Newfane	Holbrook	96.5	98	95	4010
XXX	W. J. Boyce & Co., Woodstock	Holbrook	96.5	97.4	86.5	4945
———	C. C. Holmes, Waterbury	Holbrook	80	91.8	81	22810
———	H. G. Folsom & Co., St. Albans	Johnson	98.1	97.2	90.5	5490
Anchor	H. H. Cushman, Rochester	Morehouse	D	99.4	95	180
———	M. P. Perley & Co., Enosburg Falls	Morehouse	99.5	98.4	69.5	715
Mammoth	B. F. Whelden's Sons, Ludlow	Nung.-Dick.	98(V)	98.4	94	2160
———	P. D. Pike & Son, Stowe	Nung.-Dick.	E	98.8	93.5	720
———	B. F. Whelden's Sons, Ludlow	Nung.-Dick.	98(V)	98.8	96	1520
———	Richmond Farmers' Corp., Richmond	Salzer	F*	97.8	91.5	1710

*Private purchase.

RED CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Climax	Story & Barkyoumb, St. Albans	Small	99.04	97.4	92	6920
Climax Superfine	Macdiarmid & Co., Newport	Small	...	97.5	86.5	800
Eclipse	Macdiarmid & Co., Newport	Small	...	98	70	3030
Eclipse	Griswold & Mackinnon, St. Johnsbury	Small	98.5	97.6	93.5	6375
Kaiser	Griswold & Mackinnon, St. Johnsbury	Small	98	92	88.5	18620
Arc	City Feed Co., St. Albans	Stanford	97	99.1	93	810
Arc	S. P. Curtis & Son, Rutland	Stanford	97.68	99.2	92	1170
Arc	Miles, MacMahon & Son, Stowe	Stanford	99.03	99.5	88.5	630
Arc	H. C. Royce, Sheldon Springs	Stanford	97	98.8	91.5	2010
Arc	S. B. Taylor, Manchester Depot	Stanford	97.33	99.9	91	90
Arc	J. E. Wagner, Milton	Stanford	97	98.6	91	2915
Honor	W. H. Stearns, Johnson	Stanford	99	99.4	90.5	1210
Reliable	J. E. Foster, Underhill	Stanford	97.07	97.4	92	1070
Reliable	Miles, MacMahon & Son, Stowe	Stanford	95.58	98.2	86	1440
Reliable	W. C. Marsh, Sheldon	Stanford	...	98.7	92.5	2430
99	E. E. Freeman, Waterbury Center	Stanford	99	98.8	90.5	700
———	H. P. Munson, Morrisville	Stanford	92.8	95.6	89.5	7930
Eureka	F. D. Lapelle & Co., Swanton	Whit.-Eck.	99.5	99.3	94	180
Eureka	T. C. Jennison, Sheldon	Whit.-Eck.	...	99.65	98	265
77	J. W. Jones & Co., Burlington	Whit.-Eck.	98.6	98.4	94.5	990
Eureka	A. L. Wood & Son, Woodstock	Whit.-Eck.	99.5	99.5	95	900
Pan-American	F. D. Lapelle & Co., Swanton	Whit.-Eck.	97.5	98.2	91	4145
Mammoth	H. N. Gray, Cambridge	Whit.-Eck.	97	97.6	94	4455
Globe	E. W. Bailey & Co., Montpelier	?	....	99.65	90.5	480
———	LaFountain, Woolson Co., Windsor	?	97	92.5	23.5	....
Ace	Griswold & Mackinnon, St. Johnsbury	?	99.25	99.9	96.5	90
Eureka	E. W. Bailey & Co., Montpelier	?	98	98.81	94.5	....

CORN

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Early Mastodon	W. F. Cunningham, St. Albans	Bailey	B	99.97	81.5	....
Improved Leaming, Field	E. W. Bailey & Co., Montpelier	Bailey	B	98.69	93	....
King of the Earliest, Field	E. W. Bailey & Co., Montpelier	Bailey	B	99.99	99.5	....
Pride of the North	O. G. Phelps & Co., Milton	Bailey	B	99.93	93	....
Red Cob, Fodder	E. W. Bailey & Co., Montpelier	Bailey	B	98.55	91.5	....
Sanford White Flint	J. E. Foster, Underhill	Bailey	B	99.98	96	....
Sanford White Flint	H. C. Skeels & Co., Swanton	Bailey	B	92.5	100	....
White	Strong & Goddard, Hyde Park	Bailey	98	98.3	82	....
Sanford	M. P. Perley & Co., Enosburg Falls	Breck	99	99.41	91.5	....
Sanford Flint	E. B. Williams & Co., Jericho	Breck	99	99.12	94	....
Sanford Flint	J. W. Jones & Co., Burlington	Breck	98	99.57	94.5	....
Burlington Dent	H. O. Holt & Co., Richford	Champlain	95	99.41	88.5	....
Burlington Dent	H. C. Skeels & Co., Swanton	Champlain	95	99.85	89	....
Burlington Silo, Flint	D. H. McHugh, Middlebury	Champlain	95	99.19	77.5	....
Earliest Burlington Dent	S. P. Curtis & Son, Rutland	Champlain	99.95	98.18	58.5	....
Longfellow Yellow Flint	Trumbull & Pease, White River Junction	Champlain	95	100	86.5	....
North Sanford	H. T. Brown, Ludlow	Champlain	95	99.79	94	....
Sanford	Berry & Jones, Montpelier	Champlain	95	99.77	84	....
Sanford Special R. I.	R. L. Clark, Barre	Champlain	95	100	99	....
100-Day Dent	City Feed Co., St. Albans	Champlain	99.95	97.81	74	....
———	Fred Davis, Plainfield	Cobb	98	98.12	87	....
Early Goliath	E. T. Seabury Estate, Waterbury	Conklin	99.14	99.01	95.5	....
Imperial Pride	E. T. Seabury Estate, Waterbury	Conklin	99.24	98.27	90.5	....
White Sanford	E. T. Seabury Estate, Waterbury	Conklin	99.26	98.93	93.5	....
Leaming	H. O. Holt & Co., Richford	Dickinson	98	98.93	86	....
Pride, Fodder	A. H. McLeod Milling Co., St. Johnsbury	Dickinson	99	99.21	94	....
Red Cob	Griswold & Mackinnon, St. Johnsbury	Dickinson	99	97.89	99.5	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Sanford	H. O. Holt & Co., Richford	Dickinson	98	99.41	91.5	....
Sanford Flint	Griswold & Mackinnon, St. Johnsbury	Dickinson	99	99.37	90	....
———	Valley Grain Co., Brattleboro	Dickinson	H	99.6	90	....
Eureka	A. N. Washburn, Bethel	Emerson	99	99.18	92.5	....
Pride of the North	Geo. Shorey & Son, Lyndonville	Emerson	99	98.71	93.5	....
Sanford	Vermont Marble Co., Proctor	Emerson	98	99.51	86	....
Pride of Nashua	J. E. Wagner, Milton	Gunson	94	98.81	89.5	....
Pride of Nashua	E. D. Ricker ..... Groton	Gunson	94	98.92	96	....
Leaming	C. MacFarland & Son, Barton	Holbrook	85	98.83	84.5	....
Sanford Flint	C. MacFarland & Son, Barton	Holbrook	99	99.12	96	....
Sanford White	N. M. Batchelder, Newfane	Holbrook	...	98.52	100	....
———	Farmers' Exchange ..... Bradford	Ide	95	98.63	88	....
Sanford	H. G. Folsom & Co., St. Albans	Johnson	98	98.53	92.5	....
Golden Nugget	W. B. Ladd, Enosburg Falls	Michigan	99.95	99.47	87	....
Golden Nugget	Mt. Mansfield Cream'y Co., Stowe	Michigan	K	98.69	74.5	....
Michigan Golden Dent	Hardwick Hardware Co., Hardwick	Michigan	K	99.21	96.5	....
Mosher's Vermont Dent	W. B. Ladd, Enosburg Falls	Michigan	99.95	99.91	97.5	....
Pride of Nashua	Half Century Store Co., Randolph	Michigan	K	99.77	94.5	....
Sanford	Mt. Mansfield Cream'y Co., Stowe	Michigan	K	99.51	95	....
Vermont	Half Century Store Co., Randolph	Michigan	K	99.57	95.5	....
Vermont Dent	T. C. Jennison, Sheldon	Michigan	K	99.43	98	....
Yellow Flint	G. H. Pelkey, St. Albans	Michigan	K	99.38	81	....
———	Farmers' Exchange, Bradford	Michigan	95	99.63	98	....
King of the Earliest	J. O. Middlebrook & Sons, Burlington	Middlebrook	95	99.01	90	....
Leaming	E. C. Dyke, Bristol	Middlebrook	95	97.79	98	....
Sanford	F. A. Farnsworth & Co., Middlebury	Middlebrook	94	98.69	92.5	....
Sanford	J. O. Middlebrook & Sons, Burlington	Middlebrook	95	97.04	96	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
90-Day Dent	E. C. Dyke, Bristol	Middlebrook	95	98.8	93	....
90-Day Dent	J. O. Middlebrook & Sons, Burlington	Middlebrook	95	99.31	86.5	....
Cuban Giant	E. W. Bailey & Co., Montpelier	Morehouse	99.5	97.47	93	....
Eureka	M. P. Perley & Co., Enosburg Falls	Morehouse	98	95.77	88	....
Golden Nugget	M. P. Perley & Co., Enosburg Falls	Morehouse	99	98.13	90	....
Leaming	J. O. Middlebrook & Sons, Burlington	Morehouse	95	97.84	95	....
Michigan Golden Dent	M. P. Perley & Co., Enosburg Falls	Morehouse	98	100	81	....
Minnesota Special	M. P. Perley & Co., Enosburg Falls	Morehouse	99	96.25	97	....
St. Charles Red Cob	M. P. Perley & Co., Enosburg Falls	Morehouse	98	97.33	96	....
———	E. W. Bailey & Co., Montpelier	Morehouse	99.5	99.71	93	....
Eureka	H. O. Holt & Co., Richford	Page	99	100	99	....
High Bred Sanford White Flint	W. J. Brown & Son, Bristol	Page	M	98.05	97	....
Improved Leaming	W. J. Brown & Son, Bristol	Page	M	99.04	92	....
Page's Eureka	Clark & Davidson, Groton	Page	L	99.63	94	....
Sanford	O. G. Phelps & Co., Milton	Phelps	90	99.08	98	....
8-Row Field	O. G. Phelps & Co., Milton	Phelps	90	98.88	95	....
Eureka	E. J. Davis, Chester Depot	Rice	N	99.06	90.5	....
Eureka	W. C. Landon & Co., Rutland	Rice	99.09	96.86	88.5	....
Leaming	E. J. Davis, Chester Depot	Rice	N	97.45	92.5	....
Leaming	A. H. McIntyre, Brandon	Rice	90	96.36	93.5	....
Leaming	W. C. Landon & Co., Rutland	Rice	96.47	97.44	85.5	....
Longfellow	H. G. Wilson, St. Albans	Rice	N	99.02	73	....
Sanford	A. H. McIntyre, Brandon	Rice	90	97.49	92.5	....
Sanford White	R. L. Clark, Barre	Rice	N	98.28	82.5	....
Sanford White	E. J. Davis, Chester Depot	Rice	N	99.61	86	....
Sanford White	W. C. Landon & Co., Rutland	Rice	98.7	97.64	75.5	....
8-Row Canada	W. C. Landon & Co., Rutland	Rice	97.68	98.97	98.5	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
8-Row Canada	Hatch Hardware Co., St. Albans	Rice	N	98.13	98.5	....
90-Day Golden Dent	Hatch Hardware Co., St. Albans	Rice	N	98.2	83	....
100-Day Golden Dent	W. C. Landon & Co., Rutland	Rice	98.55	97.83	95.5	....
————	Valley Grain Co., Brattleboro	Ross	P	96.75	92	....
Improved Leaming	H. W. Myers & Son, Bennington	Sherman	Q	98.11	88.5	....
Longfellow Yellow Flint	H. W. Myers & Son, Bennington	Sherman	Q	97.67	95	....
Pride of the North	H. W. Myers & Son, Bennington	Sherman	Q	99.21	92	....
Longfellow Flint	Alexander Peltier, Highgate	Slayton	99	98.61	91.5	....
Early Canada Flint	L. S. Robie, Hardwick	Stanford	90	98.03	92.5	....
Early Mastodon	Alexander Peltier, Highgate	Stanford	90	95.3	84	....
Early Triumph	E. M. Bixby & Son, Poultney	Stanford	90	99.17	91	....
Early Triumph	T. C. Jennison, Sheldon	Stanford	R	99.02	97	....
Early Triumph	F. C. Pettis & Co., North Troy	Stanford	R	98.72	98.5	....
Eureka	S. P. Curtis & Son, Rutland	Stanford	95	97.45	88.5	....
Eureka	W. B. Ladd, Enosburg Falls	Stanford	90	98.47	95.5	....
Golden Dent	J. N. Burdick, Wallingford	Stanford	90	94.3	96	....
Gold Nugget	J. G. Turnbull Co., Orleans	Stanford	90	96.04	98.5	....
Imported Early Triumph	J. E. Foster, Underhill	Stanford	90	98.49	97	....
Improved Leaming	J. N. Burdick, Wallingford	Stanford	90	99.32	84.5	....
Improved Leaming	A. N. Washburn, Bethel	Stanford	90	96.99	89.5	....
Improved Longfellow Flint	A. N. Washburn, Bethel	Stanford	90	98.92	98.5	....
Improved Pride of the North	E. M. Bixby & Son, Poultney	Stanford	90	96.9	92	....
Improved Sanford Flint	A. N. Washburn, Bethel	Stanford	90	98.87	96.5	....
Leaming	Alexander Peltier, Highgate	Stanford	90	96.99	95.5	....
Longfellow Flint	S. P. Curtis & Son, Rutland	Stanford	95	*86.31	82.5	....
Longfellow Flint	L. S. Robie, Hardwick	Stanford	90	98.44	96	....

*Worm eaten.

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Michigan Golden Dent	W. B. Ladd, Enosburg Falls	Stanford	90	96.2	97.5	....
Pride of the North	G. H. Pelkey, St. Albans	Stanford	90	98.66	95	....
Northern Wonder Flint	J. N. Burdick, Wallingford	Stanford	90	96.62	88.5	....
Northern Wonder Flint	W. M. Taylor, Derby Center	Stanford	90	93.12	90	....
Pride of Nashua	W. P. Cunningham, St. Albans	Stanford	90	98.91	97	....
Sanford	S. P. Curtis & Son, Rutland	Stanford	95	97.67	92.5	....
Sanford Flint	W. L. Ware & Co., Chester	Stanford	90	99.41	96	....
Stanford Golden Dent	T. C. Jennison, Sheldon	Stanford	90	97.14	97.5	....
Stanford High Bred 100-Day Dent	Berry & Jones, Montpelier	Stanford	90	96.75	95.5	....
Stanford White Flint	T. C. Jennison, Sheldon	Stanford	R	97.01	96.5	....
Stowell's Evergreen	L. S. Robie, Hardwick	Stanford	90	98.2	80	....
Whitecap Dent	Alexander Peltier, Highgate	Stanford	90	97.77	93.5	....
Sanford	W. B. Ladd, Enosburg Falls	Sweat-Com.	90	98.49	96	....
Early Mastodon	E. Lane & Son, Newport	Whit.-Eck.	90	99.03	86	....
Flint	B. F. Whelden's Sons, Ludlow	Whit.-Eck.	98	99.14	99.5	....
St. Charles Fancy Red	E. W. Bailey & Co., Montpelier	?	98	99.3	92.5	....
Leaming	G. H. Pelkey, St. Albans	?	....	99.72	88.5	....
		MILLET				
Old Home Japanese	W. P. Eames, Newfane	Abbott	96	97.92	85.5	3395
Japanese	J. E. Foster, Underhill	Bailey	96	96.79	90	5030
Japanese	G. J & J. A. Soules, Richmond	Barnes	...	99.9	85	1050
Hungarian	B. S. Fullington, Johnson	Breck	G	98.45	72.5	1565
Japanese	B. S. Fullington, Johnson	Breck	98	99.91	92.5	1095
Japanese	E. E. Fish, Richmond	Breck	G	99.91	88	1070
———	A. A. Newcomb, Waterbury	Breck	G	99.89	93	2415

MILLET (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
German	Combination Cash Store, Manchester Center	Conklin	99.5	99.82	76.5	70
Japanese	Lovell & Brown, Brattleboro	Conklin	97.25	99.7	80.5	2740
Japanese	E. T. Seabury Estate, Waterbury	Conklin	97.5	99.75	83	2875
Japanese	Vermont Marble Co., Proctor	Dibble	W	99.84	94.5	3480
German	Valley Grain Co., Brattleboro	Dickinson	98	98.44	87	890
Hungarian	Valley Grain Co., Brattleboro	Dickinson	98.8	99.89	79.5	2955
Hungarian	Burditt Bros., Rutland	Dickinson	98	99.96	89.5	1225
Japanese	Burditt Bros., Rutland	Dickinson	98	99.89	93.5	1650
Japanese	H. A. Slayton & Co., Morrisville	Dickinson	96	96.51	89	4680
Japanese	Trombley & Colton, Orleans	Emerson	S	98.34	86	2340
Japanese	S. E. Clark, Wells River	Emerson	T	89.46	92.5	23590
Hungarian	Berry & Jones, Montpelier	Holbrook	97	99.96	78	375
Hungarian X	Howard Hardware Co., Bellows Falls	Holbrook	95	99.91	76.5	1170
Hungarian XX	Clark & Davidson, Groton	Holbrook	97	99.93	80	665
Japanese	H. T. Brown, Ludlow	Holbrook	89	94.9	87.5	11350
Japanese	E. C. Dyke, Bristol	Middlebrook	96	96.48	88	4110
Hungarian	Griswold & Mackinnon, St. Johnsbury	Small	98	99.83	75	2530
Japanese	Griswold & Mackinnon, St. Johnsbury	Small	99	97.04	11.5	5710
Choice German	J. G. Turnbull Co., Orleans	Stanford	98.39	99.95	91	295
German	S. B. Taylor, Manchester Depot	Stanford	98	99.93	96.5	150
Hungarian	S. B. Taylor, Manchester Depot	Stanford	97	99.83	86	1610
Hungarian	A. N. Washburn, Bethel	Stanford	92.4	99.89	76.5	2550
Japanese	J. E. Foster, Underhill	Stanford	96.64	97.16	70	3950
Japanese	T. C. Jennison, Sheldon	Stanford	95.3	97.47	70.5	5400
Japanese	E. T. Brown, Woodstock	Stanford	98	98.32	93.5	2550
Japanese	H. W. Myers & Son, Bennington	Stanford	95.5	98.33	68.5	2940

MILLET (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Japanese	S. B. Taylor, Manchester Depot	Stanford	95.34	97.5	64.5	7065
Japanese	Valley Grain Co., Brattleboro	Valley Gra.	96	96.86	87.5	5930
Hungarian	B. F. Whelden's Sons, Ludlow	Whit.-Eck.	98	99.84	73.5	2680
Hungarian	H. W. Myers & Son, Bennington	Whit.-Eck.	97	99.89	60	1800
Japanese	F. D. Lapelle & Co., Swanton	Whit.-Eck.	97	95.16	75.5	7665
Japanese	A. L. Wood & Son, Woodstock	Whit.-Eck.	91	94.4	45	10370
Japanese	C. P. Robinson, Brandon	Whit.-Eck.	95	94.56	26	12485
Hungarian	E. W. Bailey & Co., Montpelier	?	....	99.73	76	164
Japanese	E. W. Bailey & Co., Montpelier	?	93	96.98	87.5	4250
Japanese	E. W. Bailey & Co., Montpelier	?	98	98.66	88.5	1479
Japanese	S. L. Davis, Putney	?	89	94.7	89	11320
Hungarian	F. M. Kempton, Barre	?	....	99.72	80	701
Japanese	LaFountain, Woolson Co., Windsor	?	89	96.28	86	11262

OATS

———	C. O. Fowler, North Troy	Amendt	U, X	99.48	95.5	175
Recleaned	N. N. Morse & Son, Randolph	Bailey	U	99.35	98.5	165
———	T. C. Jennison, Sheldon	Bailey	U	99.4	92	85
———	L. L. Marsh, Enosburg Falls	Bailey	U	99.88	97.5	105
———	Bradford Mills, Bradford	Bradford	98	99.93	98	45
Northern Wonder	Combination Cash Store, Manchester Center	Conklin	96.38	98.09	96	85
Fancy Unsulphured	City Feed Co., St. Albans	Cox	U, Y	98.01	98	155
———	Sweat-Comings Co., Richford	Cox	(Y), 97.79	95.15	98	240
Crosby's Recleaned	F. J. Nutting, Brandon	Crosby	99.78	99.92	97.5	45
Fancy Seed	W. C. Ballou, Newfane	Crosby	99.78	99.91	97.5	45
Xtra Good	Griswold & Mackinnon, St. Johnsbury	Gris.-Mack.	98	99.75	97.5	150
Mammoth Cluster	E. D. Ricker, Groton	Gunson	80	99.97	98.5	15

OATS (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Recleaned	Ryan Bros., Milton	Johnson	U	98.2	99	425
White Mountain	L. S. Blanchard, Groton	Holbrook	99	98.93	98.5	*30
White Mountain Extra Fancy	H. W. Myers & Son, Bennington	Holbrook	99	99.19	98.5	45
Silver Mane	M. P. Perley & Co., Enosburg Falls	Morehouse	95	98.97	99	*115
Fancy Recleaned Unsulphured	N. N. Morse & Son, Randolph	St. A. Grain	U	97.28	95.5	310
Borderland	H. W. Myers & Son, Bennington	Stanford	R	98.61	96.5	115
———	W. F. Cunningham, St. Albans	Local	...	99.59	98	....
———	F. D. Lapelle & Co., Swanton	Local	97	99.42	99	70
———	H. C. Skeels & Co., Swanton	Local	...	99.96	98.5	15
———	Burditt Bros., Rutland	?	96	98.09	97.5	*219
Northern Wonder	LaFountain, Woolson Co., Windsor	?	98	98.6	95.5	131
———	LaFountain, Woolson Co., Windsor	?	....	98.75	97	96
Northern Wonder	E. E. Freeman, Waterbury Center	?	98.34	99.05	98	117

*Corn cockle present.

RED TOP

———	W. R. Eames, Newfane	Abbott	90	98	54.	58500
———	Vermont Marble Co., Proctor	Dibble	W	92.51	56.5	37875
———	S. Sherman & Son, Poultney	Crav.-Dick.	90.2	97.1	38.5	17370
Grade 30	C. C. Holmes, Waterbury	Holbrook	...	85.3	46.	*59960
XXX	The Specialty Store, North Springfield	Holbrook	86	86.62	46.5	*99700
———	C. MacFarland & Son, Barton	Holbrook	95	94.08	56	*78520
———	J. B. Adams, Randolph	?	....	90.66	63	85374
Ace	E. W. Bailey & Co., Montpelier	?	....	94.12	84.5	42897
———	LaFountain, Woolson Co., Windsor	?	....	84.4	63.5	*143550
———	Robbins & Cowles, Brattleboro	?	....	93.06	88	54348
———	M. G. Williams, Putney	?	....	83.34	74	*158468

*Ergot present; declared in some cases.

TIMOTHY

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Mastiff	W. R. Eames, Newfane	Abbott	99.5	99.52	92.5	835
Bison	S. P. Curtis & Son, Rutland	Barb.-Ben.	98	98.12	85.5	2990
Square Deal	A. H. Winslow, Bennington	Barb.-Ben.	99	98.4	86	2160
———	A. H. Winslow, Bennington	Barb.-Ben.	99.7	99.75	95	900
Liberty	B. S. Fullington, Johnson	Breck	99.5	99	87.5	2025
———	B. S. Fullington, Johnson	Breck	98	98.02	84.5	3500
———	E. E. Fish, Richmond	Breck	G	99.54	85.5	910
———	A. A. Newcomb, Waterbury Center	Breck	G	97.12	84.5	15030
Acme	Richmond Lumber Co., Richmond	Conklin	99.8	99.58	86	460
Acme	E. E. Freeman, Waterbury Center	Conklin	99.8	99.72	96.5	....
Arrow	S. K. Farr, Bristol	Conklin	99.1	98.93	85.5	1960
Bingo	E. M. Bixby & Son, Poultney	Conklin	99.95	99.97	93	....
Don	B. F. Whelden's Sons, Ludlow	Conklin	97.55	97.66	79	1260
King	Richford Lumber Co., Richford	Conklin	99.6	99.46	90	660
Rex	M. P. Perley & Co., Enosburg Falls	Conklin	98.4	98.79	85.5	400
Bell	B. Eastman, Groton	Cross, Abb.	98.5	99.59	79.5	745
Three Star	O. A. Cobb, Bridgewater Corners	Cross, Abb.	93	95.58	88.5	35200
D. B.	Vermont Marble Co., Proctor	Dibble	99.5	99.02	89.5	2900
D. B.	Don Camp, South Barre	Dibble	99.5	99.75	85.5	1710
Bison	H. A. Slayton & Co., Morrisville	Dickinson	98	98.02	90	4730
Colonial	W. B. Phelps Co., Enosburg Falls	Dickinson	98.6	98.6	94.5	2520
Globe	W. C. Landon & Co., Rutland	Dickinson	99.8	99.85	95	510
Globe	W. B. Ladd, Enosburg Falls	Dickinson	99.8	99.93	95.5	420
Honor	W. B. Ladd, Enosburg Falls	Dickinson	99.7	99.7	97.5	2575
Pine Tree	H. A. Slayton & Co., Morrisville	Dickinson	99.5	99.72	84	210
Pine Tree	W. B. Phelps Co., Enosburg Falls	Dickinson	99.5	99.44	94	930

TIMOTHY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Ace	S. Sherman & Co., Poultney	Crav.-Dick.	99.5	99.74	95.5	2040
Globe	E. M. Bixby & Son, Poultney	Crav.-Dick.	99.84	99.95	91.5	....
Monadnock	N. M. Batchelder, Newfane	Holbrook	99.5	99.06	71.5	965
Monarch	V. E. Howard, Wells River	Holbrook	99.5	99.9	90.5	225
Pine Tree	Strong & Goddard, Hyde Park	Holbrook	99.5	99.67	84	900
Extra Fancy White Mountain.	Berry & Jones, Montpelier	Holbrook	99	99.91	94	....
White Mountain.	C. C. Holmes, Waterbury	Holbrook	99.5	99.51	81	370
White Mountain.	Geo. Shorey & Son, Lyndonville	Holbrook	99.7	99.61	80.5	525
White Mountain.	R. O. Mudgett & Co., Essex Junction	Holbrook	99.6	99.6	70.5	350
X	W. J. Boyce & Co., Woodstock	Holbrook	93	94.16	76	36970
XX	W. J. Boyce & Co., Woodstock	Holbrook	97	97.55	72.5	3740
XXX	Lovell & Brown, Brattleboro	Holbrook	98.5	98.6	83.5	2880
10131	T. Green, Richmond	Johnson	99.51	99.70	77	....
———	C. H. Robinson, Brandon	Jones	95	92.37	86	845
Pine Tree	E. C. Dyke, Bristol	Middlebrook	99.5	99.55	91	590
———	D. H. McHugh, Middlebury	Middlebrook	99	99.08	89.5	1890
Anchor	M. P. Perley & Co., Enosburg Falls	Morehouse	99.75	99.66	85	645
Anchor	J. W. Jones & Co., Burlington	Morehouse	99.33	99.63	84	770
———	P. D. Pike & Son, Stowe	Nung.-Dick.	E	99.17	83.5	380
Pine Tree	Alexander Peltier, Highgate	Slayton	99.5	99.5	87.5	1115
———	P. D. Pike & Son, Stowe	Slayton	99	99.49	87.5	690
Climax Superfine	Macdiarmid & Co., Newport	Small	...	99.35	82	1070
———	L. S. Robie, Hardwick	Small	99.55	98.39	76	6640
Dandy	W. C. Marsh, Sheldon	Stanford	99	98.93	92	2535
Honor	H. T. Brown, Ludlow	Stanford	99.7	99.88	90	380
Liberty	City Feed Co., St. Albans	Stanford	99.5	99.76	89	....

TIMOTHY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Prime	E. I. Benson, Woodstock	Stanford	99	99.1	88	750
Globe	H. O. Holt & Co., Richford	Sweat-Com.	99.8	99.9	96	390
Durham	S. A. Reed, Windsor	Varick	99.5	99.21	80.5	1225
Gold Medal	W. P. Cary, Wallingford	Whit.-Eck.	99.7	99.77	88.5	....
Gold Medal	W. P. Cary, Wallingford	Whit.-Eck.	98.7	99.41	87.5	....
Gold Medal	E. Lane & Son, Newport	Whit.-Eck.	99.6	99.64	86	630
Green Mountain	E. E. Harris & Co., Morrisville	Whit.-Eck.	99.5	99.5	87	1890
Herald	E. E. Harris & Co., Morrisville	Whit.-Eck.	96	96.02	86	2910
Imperator	C. A. Leland & Son, Springfield	Whit.-Eck.	99	99.15	75	1125
Pan-American	H. M. Gray, Cambridge	Whit.-Eck.	99.5	99.37	90	370
Globe	E. W. Bailey & Co., Montpelier	?	....	99.64	96.5	327
———	E. W. Bailey & Co., Montpelier	?	....	98	75.5	4275
Pine Tree	Burditt Bros., Ludlow	?	99.5	99.55	98	381
Bison	Burditt Bros., Ludlow	?	98	99.52	89	3073
———	LaFountain, Woolson Co., Windsor	?	....	99.31	89.75	1456
Arrow	LaFountain, Woolson Co., Springfield	?	99.1	99.26	92	1500
Globe	Lovell & Brown, Brattleboro	?	97	98.9	59	452

MISCELLANEOUS

Japanese Buckwheat	B. F. Whelden's Sons, Ludlow	Whit.-Eck.	98	99.59	95	55
Japanese Buckwheat	F. M. Kempton, Barre	Whit.-Eck.	99	99	98	160
——— Buckwheat	H. C. Skeels & Co., Swanton	Local	...	99	99	180
Japanese Buckwheat	Trumbull & Pease, White River Junction	Bailey	B	99.98	99	15
Japanese Buckwheat	M. P. Perley & Co., Enosburg Falls	Morehouse	98	96.42	98	800
Buckwheat	J. O. Middlebrook & Sons, Burlington	?	95	96.65	95	1315
Clover, White	E. W. Bailey & Co., Montpelier	?	....	98.16	85.5	3110

MISCELLANEOUS (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Clover, White	LaFountain, Woolson Co., Windsor	?	96.65	97.9	91.5	1478
Clover, White	LaFountain, Woolson Co., Windsor	?	....	96.64	82.5	42569
Italian Rye Grass	J. O. Middlebrook & Sons, Burlington	Dickinson	97	99.5	*	....
Kentucky Bluegrass	R. L. Clark, Barre	Bailey	B	96.5	*	10620
Fancy Kentucky Bluegrass	W. C. Landon & Co., Rutland	Barb.-Ben.	82.09	97	*	12990
Kentucky Bluegrass	E. T. & H. K. Ide, St. Johnsbury	Dickinson	80	97.2	*	9870
Kentucky Bluegrass	A. L. Wood & Sons, Woodstock	Whit.-Eck.	85	86	*	16880
Orchard Grass	S. P. Curtis & Son, Rutland	Stanford	75	94	*	5240
Orchard Grass‡	F. D. Lapelle & Co., Swanton	Whit.-Eck.	75	93.8	*	1905
Orchard Grass	Field & Lawrence, Bellows Falls	Dickinson	....	82.68	*	5568
Orchard Grass	Robbins & Cowles, Brattleboro	?	....	92.24	*	226
Field Peas No. 1	E. T. Seabury Estate, Waterbury	Conklin	99.31	98.41	92.5	....
Canada Field Peas	Geo. Shorey & Son, Lyndonville	Holbrook	96 †	98.39	94	....
Canada Field Peas	Miles, MacMahon & Son, Stowe	Rice	†	99.98	93	....
Canada Field Peas	Trombley & Colton, Orleans	Rice	†	99.75	93.5	....
Canada Field Peas	Combination Cash Store, Manchester Center	Rice	97 †	100	94.5	....
Canada Peas	S. B. Taylor, Manchester Depot	Stanford	90 †	98.86	94.5	....
Rape	A. L. Wood & Sons, Woodstock	Whit.-Eck.	98	99.4	98	....
Spring Rye	E. T. & H. K. Ide, St. Johnsbury	Dickinson	99	98.32	97	....
——— Rye	Burditt Bros., Rutland	Dickinson	95	98.18	53.5	55
Spring Rye	E. W. Bailey & Co., Montpelier	Dwinell	B	97.9	63.5	....
Spring Rye	E. W. Bailey & Co., Montpelier	Morehouse	99.5	98.07	86	....
Winter Rye	M. P. Perley & Co., Enosburg Falls	Morehouse	99.25	97.25	95.5	....
Winter Rye	E. W. Bailey & Co., Montpelier	Morehouse	B	95.67	83.5	....
Spring Rye	B. F. Whelden's Sons, Ludlow	Whit.-Eck.	98	97.33	87	15

*No germination trials made. †No guaranty required.
‡As a matter of fact these goods were not orchard grass but awnless brome grass.

MISCELLANEOUS (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Winter Rye	J. O. Middlebrook & Sons, Burlington	Local	98	94.74	82.5	1355
Sunflower	E. W. Bailey & Co., Montpelier	Breck	†	93.6	88	45
White Blossom Sweet Clover	F. H. Gillingham, Woodstock	Dickinson	99	99.55	77.5	90
Sweet Clover	E. M. Bixby & Son, Poultney	Conklin	98.5	99.2	86	90
Sweet Clover	C. E. Robinson, Brandon	Whit.-Eck.	97	99.2	88	90
Sweet Clover	A. L. Wood & Sons, Woodstock	Whit.-Eck.	98	99.55	88	....
Wheat	H. W. Myers & Son, Bennington	Barb.-Ben.	97	99.99	97	....
Bluestem Wheat	A. H. McLeod Milling Co., St. Johnsbury	Dickinson	99	98.56	92.5	....
Spring Wheat	E. T. & H. K. Ide, St. Johnsbury	Dickinson	99.8	98.94	94.5	....
Spring Scotch Wheat	M. P. Perley & Co., Enosburg Falls	Morehouse	99.5	99.96	95.5	30
Spring Wheat	E. W. Bailey & Co., Montpelier	Park & Pol.	...	98.22	68	290
Wheat	F. M. Kempton, Barre	Whit.-Eck.	98.6	98.95	96.5	15
Wheat	E. W. Bailey & Co., Montpelier	?	....	96.16	97	*2969

*Corn cockle.
†No guaranty required.

VI. ANALYSES OF AGRICULTURAL SEED (BY WHOLESALERS)

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
ABBOTT GROCERY CO., KEENE, N. H.					
Alsike Clover	Mastiff	92	95.5	86.5	8775
Red Clover	Old Home	96	98.62	68.5	2230
Millet	Old Home Japanese	96	97.92	85.5	3395
Redtop	———	90	98	54	58500
Timothy	Mastiff	99.5	99.52	92.5	835
J. B. ADAMS, RANDOLPH, VT.					
Redtop	———	....	90.66	63	85374
AMENDT MILLING CO., MONROE, MICH.					
Oats	———	U	99.48	95.5	175
BADGER SEED CO., ———.					
Alsike Clover	Badger	99	97.5	86.5	2700
E. W. BAILEY & CO., MAIN ST., MONTPELIER, VT.					
Alsike Clover	Ace	B	96	90.5	2025
Red Clover	Ace	B	98	92	2425
	Ace	99.5	99.6	86.5	270
	Globe	...	99.65	90.5	480
	Eureka	98	98.81	94.5	....
Corn	Early Mastodon	B	99.97	81.5	....
	Improved Leaming, Field.	B	98.69	93	....
	King of the Earliest, Field	B	99.99	99.5	....
	Pride of the North	B	99.93	93	....
	Red Cob, Fodder	B	98.55	91.5	....
	Sanford White Flint	B	99.98	96	....
	Sanford White Flint	B	92.5	100	....
	St. Charles Fancy Red	98	99.3	92.5	....
	White	98	98.3	82	....
Millet	Japanese	96	96.79	90	5030
	Hungarian	...	99.73	76	164
	Japanese	98	96.98	87.5	4250
	Japanese	98	98.66	88.5	1479
Oats	Recleaned	U	99.35	98.5	165
	———	U	99.4	92	85
	———	U	99.88	97.5	105
Redtop	Ace	...	94.12	84.5	42897
Timothy	Globe	...	99.64	96.5	327
	———	...	98	75.5	4275
Buckwheat	Japanese	B	99.98	99	15
Bluegrass	Kentucky	B	96.5	*	10620
White Clover	———	...	98.16	85.5	3110
Wheat	———	...	96.16	97	*2969

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
BARBER & BENNETT, ARCH AND CHURCH STS., ALBANY, N. Y.					
Alsike Clover	———	99	98.5	97	225
Red Clover	———	99	99.2	95.5	540
Timothy	Bison	98	98.12	85.5	2990
	Square Deal	99	98.4	86	2160
	———	99.7	99.75	95	900
Bluegrass	Fancy Kentucky	82.09	97	*	12990
Wheat	———	97	99.99	97	....
O. J. BARNES CO., 50 WELLINGTON ST., MALONE, N. Y.					
Millet	Japanese	....	99.9	85	1050
BRADFORD MILLS, BRADFORD, VT.					
Oats	———	98	99.93	98	45
JOS. BRECK & SONS CORPORATION, 51-52 NORTH MARKET ST., BOSTON, MASS.					
Red Clover	———	G	97.9	84.5	3585
Corn	Sanford Flint	99	99.12	94	....
	Sanford Flint	98	99.57	94.5	....
	Sanford	99	99.41	91.5	....
Millet	Hungarian	G	98.45	72.5	1565
	Japanese	98	99.91	92.5	1095
	Japanese	G	99.91	88	1070
	———	G	99.89	93	2415
Timothy	Liberty	99.5	99	87.5	2025
	———	98	98.02	84.5	3500
	———	G	99.54	85.5	910
	———	G	97.12	84.5	15030
Sunflower	———	†	93.6	88	15
BURDITT BROS., RUTLAND, VT.					
Alsike Clover	Kaiser	92	96	88.5	3040
Red Clover	Ace	98	99.2	95	715
Oats	———	96	98.09	97.5	219
Timothy	Pine Tree	99.5	99.55	98	381
	Bison	98	99.52	89	3073

*Not determined.

†No guaranty required.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
CHAMPLAIN SEED CO., 191 BANK ST., BURLINGTON, VT.					
Corn	Burlington Dent	95	99.41	88.5	....
	Burlington Silo, Flint	95	99.19	77.5	....
	Burlington Dent	95	99.85	89	....
	Earliest Burlington Dent	99.95	98.18	58.5	....
	Longfellow Yellow Flint	95	100	86.5	....
	Northern Sanford	95	99.79	94	....
	Sanford	95	99.77	84	....
	Sanford Special R. I.	95	100	99	....
	100-Day Dent	99.95	97.81	74	....
W. F. COBB CO., FRANKLIN, MASS.					
Corn	———	98	98.12	87	....
E. W. CONKLIN & SON, 28-48 MONTGOMERY ST., BINGHAMTON, N. Y.					
Alfalfa	IXL	99.26	99.6	92	....
Barley	Six-Row Oderbrucker	99.42	98.15	99.5	45
Alsike Clover	———	96.25	97	89.5	3960
	———	96.25	97	84	4865
	———	96.25	96.5	87.5	7200
Red Clover	A	98.4	99	94.5	1620
	Crown	99.35	99.2	93.5	720
	Crown Mammoth	99.35	99.2	94	450
	Etna	92.8	93.8	88.5	12330
	Pilot Mammoth	98.5	98.53	93.5	1750
	———	98	97.78	95.5	2085
Corn	Early Goliath	99.14	99.01	95.5	....
	Imperial Pride	99.24	98.27	90.5	....
	White Sanford	99.26	98.93	93.5	....
Millet	German	99.5	99.82	76.5	70
	Japanese	97.5	99.75	83	2875
	Japanese	97.25	99.7	80.5	2740
Oats	Northern Wonder	96.38	98.09	96	85
Timothy	Acme	99.8	99.58	86	460
	Acme	99.8	99.72	96.5	....
	———	...	99.31	90	1456
	Arrow	99.1	99.26	92	1500
	Globe	97	98.9	59	452
Buckwheat	———	95	96.65	95	1315
Clover, White	———	....	98.16	85.5	3110
	———	96.65	97.9	91.5	1478
	———	....	96.64	82.5	42569
	Arrow	99.1	98.93	85.5	1960
	Bingo	99.95	99.97	93	....
	Don	97.55	97.66	79	1260
	King	99.6	99.46	90	660
	Rex	98.4	98.79	85.5	400
Field Peas	No. 1	99.31	98.41	92.5	....
Sweet Clover	———	98.5	99.2	86	90

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
CHAS. M. COX CO., CHAMBER OF COMMERCE, BOSTON, MASS.					
Oats	Fancy Unsulphured	U	98.01	98	155
	———	97.79	95.15	98	240
S. L. DAVIS, PUTNEY, VT.					
Millet	Japanese	89	94.7	89	11320
CRAVER-DICKINSON SEED CO., 329-351 GANSON ST., BUFFALO, N. Y.					
Alfalfa	Globe	99.56	99.2	78	90
Alsike Clover	Ace	....	97.5	85	1350
	———	88.25	94.5	83	8030
Redtop	———	90.2	97.1	38.5	17370
Timothy	Ace	99.5	99.74	95.5	2040
	Globe	99.84	99.95	91.5	....
E. CROSBY & CO., BRATTLEBORO, VT.					
Oats	Crosby's Recleaned	99.78	99.92	97.5	45
	Fancy Seed	99.78	99.91	97.5	45
CROSS, ABBOTT CO., WHITE RIVER JUNCTION, VT.					
Alsike Clover	———	C	97	86	1125
Red Clover	Very Best	93	97.2	93.5	4530
	———	C	98	95.5	3415
Timothy	Bell	98.5	99.59	79.5	745
	Three Star	93	95.58	88.5	35200
EDWARD F. DIBBLE, HONEOYE FALLS, N. Y.					
Alfalfa	———	99.5	99.9	83.5	....
Red Clover	———	99.5	98.6	92.5	630
	———	99.5	98.8	95.5	1080
Millet	Japanese	...	99.84	94.5	3480
Redtop	———	...	92.51	56.5	37875
Timothy	D. B.	99.5	99.02	89.5	2900
	D. B.	99.5	99.75	85.5	1710
DELL B. DWINELL, EAST CALAIS, VT.					
Rye	Spring	B	97.9	63.5	....

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
	ALBERT DICKINSON CO., CHICAGO, ILL.				
Alfalfa	Ace	99.3	98.8	90.5	900
	Globe	99.45	99.5	92	....
	Pine Tree	99.6	99.1	81	....
	Pine Tree	99.5	99.55	84	90
Barley	Six-Row	99.5	97.9	100	15
	Six-Row	99.4	99.28	94	15
	Six-Row	99	97.98	92.5	†40
	Two-Row	98	97.96	84	....
Alsike Clover	Ace	94	96.5	89	1384
	Ace	95	96.5	94	9115
	Globe	98	97	92.5	1800
	Kaiser	88	93	85.5	13210
	Queen	88	89.5	81.5	38360
	Queen	88	90	86	33420
	————	93.34	97	86.5	1560
Red Clover	Ace Mammoth	98	99.5	92.5	360
	Ace	97	98.2	78.5	2580
	Globe	99	98.8	85.5	1070
	Kaiser	97	97.4	83.5	4250
	N. N. Y.	98	98	84.5	3605
	Queen	95	96.6	79.5	6590
	Queen	96	97.1	87.5	6930
	Queen	95	96.4	81.5	5400
	————	98.23	99.2	85	805
	————	98	98.7	84	815
	————	95.15	96.6	78.5	7290
Corn	Leaming	98	98.93	86	....
	Pride, Fodder	99	99.21	94	....
	Red Cob	99	97.89	99.5	....
	Sanford	98	99.41	91.5	....
	Sanford Flint	99	99.37	90	....
	————	H	99.6	90	....
Millet	German	98	98.44	87	890
	Hungarian	98.8	99.89	79.5	2955
	Hungarian	98	99.96	89.5	1225
	Japanese	98	99.89	93.5	1650
	Japanese	96	96.51	89	4680
Timothy	Bison	98	98.02	90	4730
	Colonial	98.6	98.6	94.5	2520
	Globe	99.8	99.93	95.5	420
	Globe	99.8	99.85	95	510
	Honor	99.7	99.7	97.5	2575
	Pine Tree	99.5	99.72	84	210
	Pine Tree	99.5	99.44	94	930
Grass	Italian Rye	97	99.5	*	....
Bluegrass	Kentucky	80	97.2	*	9870
Orchard Grass	————	....	82.68	*	5568
	————	....	96.24	*	226
Wheat	————	....	96.16	97	†2969
Rye	Spring	99	98.32	97	....
	————	95	98.18	53.5	55
Sweet Clover	White Blossom	99	99.55	77.5	90
Wheat	Bluestem	99	98.56	92.5	....
	Spring	99.8	98.94	94.5	....

*Not determined.
†Corn cockle present.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
THOMAS W. EMERSON, BOSTON, MASS.					
Corn	Eureka	99	99.18	92.5	....
	Pride of the North	99	98.71	93.5	....
	Sanford	98	99.51	86	....
Millet	Japanese	S	98.34	86	2340
	Japanese	T	89.46	92.5	23590
E. E. FREEMAN, WATERBURY CENTER, VT.					
Oats	Northern Wonder	98.34	99.05	98	117
Timothy	Acme	99.8	99.72	96.5	....
GRISWOLD & MACKINNON, ST. JOHNSBURY, VT.					
Red Clover	Ace	99.9	99.25	96.5	90
Oats	Xtra Good	98	99.75	97.5	150
L. P. GUNSON & CO., ROCHESTER, N. Y.					
Corn	Pride of Nashua	94	98.81	89.5	....
	Pride of Nashua	94	98.92	96	....
Oats	Mammoth Cluster	80	99.97	98.5	15
HOLBROOK GROCERY CO., KEENE, N. H.					
Alfalfa	White Mountain	99.5	99.95	90	90
Barley	Six-Row	99.5	98.32	99	75
Alsike Clover	White Mountain	98.5	98.9	92.5	675
	White Mountain	98	99.25	97	2250
	White Mountain	98.5	99.1	91.5	645
	X	70	84	56.5	19570
	XX	80	86.5	80.5	25670
	XXX	90	95	86.5	19890
	XXX	87	94.5	79	27000
	80	80	89	76	21050
Red Clover	Ace	98	98.4	91	2520
	White Mountain Mammoth	99.55	96.6	22	2700
	White Mountain	99.5	99.2	95.5	720
	White Mt. Extra Fancy.	99.5	99.4	96	450
	XX	90	94.4	85.5	11430
	XXX	96.5	98	95	4010
	XXX	96.5	97.4	86.5	4940
	————	80	91.8	81	22810
Corn	Leaming	85	98.83	84.5	....
	Sanford Flint	99	99.12	96	....
	Sanford White	....	98.52	100	....
Millet	Hungarian XX	97	99.93	80	665
	Hungarian X	95	99.91	76.5	1170
	Hungarian	97	99.96	78	375
	Japanese	89	93.9	87.5	11350
Oats	White Mountain	99	98.93	98.5	†30

†Corn cockle present.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
HOLBROOK GROCERY CO. (CONTINUED)					
Oats	Extra Fancy White Mt.	99	99.19	98.5	45
Redtop	Grade 30	....	85.3	46	*58960
	XXX	86	86.62	46.5	*99700
	———	95	94.08	56	*78520
Timothy	Monadnock	99.5	99.06	71.5	965
	Monarch	99.5	99.9	90.5	225
	Pine Tree	99.5	99.67	84	900
	Extra Fancy White Mt.	99	99.91	94	....
	White Mountain	99.5	99.51	81	370
	White Mountain	99.7	99.61	80.5	525
	White Mountain	99.6	99.6	70.5	350
	X	93	94.16	76	36970
	XX	97	97.55	72.5	3740
	XXX	98.5	98.6	83.5	2880
Peas	———	96	98.39	94	....
E. T. & H. K. IDE, ST. JOHNSBURY, VT.					
Corn	———	95	98.63	88	....
W. B. JOHNSON & CO., ESSEX JUNCTION, VT.					
Alsike Clover	———	96.31	98	89	1125
Red Clover	———	98.1	97.2	90.5	5490
Corn	Sanford	98	98.53	92.5	....
Oats	Recleaned	U	98.2	99	425
Timothy	10131	99.51	99.70	77	....
A. G. & C. W. JONES, BRANDON, VT.					
Timothy	———	95	92.37	86	845
F. M. KEMPTON, BARRE, VT.					
Barley	Six-Row	98	99.28	100	54
Millet	Hungarian	...	99.72	80	701

*Ergot present.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
LAFOUNTAIN, WOOLSON CO., WINDSOR, VT.					
Alsike Clover	————	....	98.9	93.5	5352
Red Clover	————	....	97	92.5	2343
Millet	Japanese	89	96.28	86	11262
Oats	Northern Wonder	98	98.6	95.5	131
Oats	————	...	98.75	97	96
Redtop	————	...	84.4	63.5	*143550
Timothy	Arrow	99.1	99.26	92	1500
	————	...	99.31	89.7	1456
White Clover	————	96.65	97.9	91.5	1478
	————	...	96.64	82.5	42569
LOVELL AND BROWN, BRATTLEBORO, VT.					
Timothy	Globe	97	98.9	59	452
A. B. LYMAN, EXCELSIOR, MINN.					
Alfalfa	Grimm	A	99.8	75.5	....
	Grimm Hardy	A	99.64	78	....
MICHIGAN SEED CO., RICHFORD, VT.					
Corn	Golden Nugget	99.95	99.47	87	....
	Golden Nugget	K	98.69	74.5	....
	Michigan Golden Dent	K	99.21	96.5	....
	Mosher's Vermont Dent	99.95	99.91	97.5	....
	Pride of Nesia	K	99.77	94.5	....
	Sanford	K	99.51	95	....
	Vermont	K	99.57	95.5	....
	Vermont Dent	K	99.43	98	....
	Yellow Flint	K	99.38	81	....
	————	95	99.63	98	....
J. O. MIDDLEBROOK & SONS, COLLEGE ST., BURLINGTON, VT.					
Corn	King of the Earliest	95	99.01	90	....
	Leaming	95	97.79	98	....
	Sanford	94	98.69	92.5	....
	Sanford	95	97.04	96	....
	90-Day Dent	95	98.8	93	....
	90-Day Dent	95	99.31	86.5	....
Millet	Japanese	96	96.48	88	4110
Timothy	Pine Tree	99.5	99.55	91	590
	————	99	99.08	89.5	1890
Buckwheat	————	95	96.65	95	1315

*Ergot present.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
W. H. MOREHOUSE & CO., 46-47 PRODUCE EXCHANGE, TOLEDO, OHIO					
Alfalfa	Anchor	99	99.6	84	90
Barley	Chevalier	99.5	96.31	84	60
	Six-Row	98.9	97.83	99.5	75
Alsike Clover	Anchor	D	98	86.5	450
	Bell	97	99.3	91.5	....
Red Clover	Anchor	D	99.4	95	180
	————	99.5	98.4	69.5	715
Corn	Cuban Giant	99.5	97.47	93	....
	Eureka	98	95.77	88	....
	Golden Nugget	99	98.13	90	....
	Leaming	95	97.84	95	....
	Michigan Golden Dent	98	100	81	....
	Minnesota Special	99	96.25	97	....
	St. Charles Red Cob	98	97.33	96	....
	————	99.5	99.71	93	....
Oats	Silver	95	98.97	99	*115
Timothy	Anchor	99.75	99.66	85	645
	Anchor	99.33	99.63	84	770
	Bison	98	99.06	80.5	1275
Buckwheat	Japanese	98	96.42	98	800
Rye	Spring	99.5	98.07	86	....
	Winter	99.25	97.25	95.5	....
	Winter	B	95.67	83.5	....
Wheat	Spring Scotch	99.5	99.96	95.5	30

*Corn cockle.

NUNGESSER-DICKINSON CO., 1203-1209 HUDSON ST., HOBOKEN, N. J.					
Alfalfa	————	97	98.8	56.5	1255
Alsike Clover	————	E	98.5	92.5	220
Red Clover	Mammoth	98	98.4	94	2160
	————	E	98.8	93.5	720
	————	98	98.8	96	1520
Timothy	————	E	99.17	83.5	380
PAGE SEED CO., GREENE, N. Y.					
Corn	Eureka	99	100	99	....
	High Bred Sanford White Flint	M	98.05	97	....
	Improved Leaming	M	99.04	92	....
	Page's Eureka	L	99.63	94	....
PARK & POLLARD CO., BOSTON, MASS.					
Wheat	Spring	....	98.22	68	290

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
G. H. PELKEY, ST. ALBANS, VT.					
Corn	Leaming	....	99.72	88.5	....
O. G. PHELPS & CO., MILTON, VT.					
Corn	Sanford	90	99.08	98	....
	Eight-Row Field	90	98.88	95	....
JEROME B. RICE SEED CO., CAMBRIDGE, N. Y.					
Corn	Eureka	N	99.06	90.5	....
	Eureka	99.09	96.86	88.5	....
	Leaming	N	97.45	92.5	....
	Leaming	90	96.36	93.5	....
	Leaming	96.47	97.44	85.5	....
	Longfellow	N	99.02	73	....
	Sanford	90	97.49	92.5	....
	Sanford White	N	98.28	82.5	....
	Sanford White	N	99.61	86	....
	Sanford White	98.7	97.64	75.5	....
	Eight-Row Canada	97.68	98.97	98.5	....
	Eight-Row Canada	N	98.13	98.5	....
	90-Day Golden Dent	N	98.2	83	....
	100-Day Golden Dent	98.55	97.83	95.5	....
Peas	Canada Field	†	99.98	93	....
	Canada Field	†	99.75	93.5	....
	Canada Field	97	100	94.5	....
ROBBINS AND COWLES, BRATTLEBORO, VT.					
Alsike Clover	————	...	90.86	92.5	3112
Redtop	————	...	93.06	87.5	54348
Orchard Grass	————	...	92.24	*	226
ROSS BROS. CO., WORCESTER, MASS.					
Corn	————	P	96.75	92	....
ST. ALBANS GRAIN CO., ST. ALBANS, VT.					
Fancy Recleaned Oats	Unsulphured	U	97.28	95.5	310
JOHN A. SALZER SEED CO., LA CROSSE, WIS.					
Alsike Clover	————	F	98	87.5	675
Red Clover	————	F	97.8	91.5	1710

†No guaranties required.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
F. A. SHERMAN, ALBANY, N. Y.					
Corn	Improved Leaming	Q	98.11	88.5	....
	Longfellow Yellow Flint	Q	97.67	95	....
	Pride of the North	Q	99.21	92	....
H. A. SLAYTON & CO., MORRISVILLE, VT.					
Corn	Longfellow Flint	99	98.61	91.5	....
Timothy	Pine Tree	99.5	99.5	87.5	1115
	———	99	99.49	87.5	690
W. H. SMALL & CO., EVANSVILLE, IND.					
Alfalfa	Eclipse	98.5	99.65	94.5	....
Alsike Clover	Climax Superfine	97.2	98.2	93.5	675
	Eclipse	....	97	94	215
Red Clover	Climax	99.04	97.4	92	6920
	Climax Superfine	....	97.5	86.5	800
	Eclipse	....	98	70	3030
	Eclipse	98.5	97.6	93.5	6375
	Kaiser	98	92	88.5	18620
Millet	Hungarian	98	99.83	75	2530
	Japanese	99	97.04	11.5	5710
Timothy	Climax Superfine	....	99.35	82	1070
	———	99.55	98.39	76	6640
STANFORD SEED CO., 93 PERRY ST., BUFFALO, N. Y.					
Alfalfa	Empire	99.5	99.8	95	90
	Honor	99.25	99	77.5	450
	Honor	98.5	99.4	86	....
Barley	Six-Row	90	97.86	78.5	15
	———	90	98.36	79	....
	Arc	96.68	98	80	....
Alsike Clover	Arc	97.29	98.5	93.5	....
	Fancy	97.29	98.1	93.5	....
	Fancy	95.84	98	93.5	....
	Fancy	97	99	86.5	....
	Queen	87	94.5	84.5	16300
	Reliable	95.75	99.15	93	215
	Reliable	95.25	97.5	83	885
	Reliable	95.65	96	89.5	....
Red Clover	Arc	97	99.1	93	810
	Arc	97.68	99.2	92	1170
	Arc	99.03	99.5	88.5	630
	Arc	97	98.8	91.5	2010
	Arc	97.33	99.9	91	90
	Arc	97	98.6	91	2915
	Honor	99	99.4	90.5	1210
	Reliable	97.07	97.4	92	1070
	Reliable	95.58	98.2	86	1440
	Reliable	....	98.7	92.5	2430
	99	99	98.8	90.5	700

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
	STANFORD SEED CO. (CONTINUED)				
	———	92.8	95.6	89.5	7930
Corn	Early Canada Flint	90	98.03	92.5	....
	Early Mastodon	90	95.3	84	....
	Early Triumph	90	99.17	91	....
	Early Triumph	R	99.02	97	....
	Early Triumph	R	98.72	98.5	....
	Eureka	95	97.45	88.5	....
	Eureka	90	98.47	95.5	....
	Golden Dent	90	94.3	96	....
	Gold Nugget	90	96.04	98.5	....
	Imported Early Triumph.	90	98.49	97	....
	Improved Leaming	90	99.32	84.5	....
	Improved Leaming	90	96.99	89.5	....
	Improved Longfellow	90	98.92	98.5	....
	Improved Pride of the North	90	96.9	92	....
	Improved Sanford Flint..	90	98.87	96.5	....
	Leaming	90	96.99	95.5	....
	Longfellow Flint	95	86.31	82.5	....
	Longfellow Flint	90	98.44	96	....
	Michigan Golden Dent...	90	96.2	97.5	....
	Pride of the North	90	98.66	95	....
	Northern Wonder Flint..	90	96.62	88.5	....
	Northern Wonder Flint..	90	93.12	90	....
	Pride of Nashua	90	98.91	97	....
	Sanford	95	97.67	92.5	....
	Sanford Flint	90	99.41	96	....
	Stanford Golden Dent....	90	97.14	97.5	....
	Stanford High Bred 100-Day Dent	90	96.75	95.5	....
	Stanford White Flint.....	R	97.01	96.5	....
	Stowell's Evergreen	90	98.2	80	....
	Whitecap Dent	90	97.77	93.5	....
Millet	Choice German	98.39	99.95	91	295
	German	98	99.93	96.5	150
	Hungarian	97	99.83	86	1610
	Hungarian	92.40	99.89	76.5	2550
	Japanese	96.64	97.16	70	3950
	Japanese	95.3	97.47	70.5	5400
	Japanese	98	98.32	93.5	2550
	Japanese	95.50	98.33	68.5	2940
	Japanese	95.34	97.5	64.5	7065
Oats	Borderland	R	98.61	96.5	115
Timothy	Dandy	99	98.93	92	2535
	Honor	99.7	99.88	90	380
	Liberty	99.5	99.76	89	....
	Prime	99	99.1	88	750
Grass	Orchard	75	94	*	5240
Peas	Canada	90†	98.86	94.5	....

*Not determined.
†Guaranty not required.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
SWEAT-COMINGS CO., RICHFORD, VT.					
Corn	Sanford	90	98.49	96	....
Timothy	Globe	99.8	99.9	96	390
VALLEY GRAIN CO., BRATTLEBORO, VT.					
Millet	Japanese	96	96.86	87.5	5930
JOHN B. VARICK CO., MANCHESTER, N. H.					
Timothy	Durham	99.5	99.21	80.5	1225
WHITNEY-ECKSTEIN SEED CO., 599-601 PERRY ST., BUFFALO, N. Y.					
Alfalfa	Eureka	99.5	99.2	94.5	90
Barley	Six-Row	98	98.34	81	....
	Two-Row	98	96.78	80	40
Alsike Clover	Eureka	98.5	98.75	95	....
	Eureka	98	98.7	86.5	1105
	Eureka	99	99.8	96	....
	Export Fancy	98.5	98	93	....
	Pan-American	97	97.8	84.5	1115
Red Clover	Eureka	99.5	99.3	94	180
	Eureka	....	99.65	98	265
	77	98.6	98.4	94.5	990
	Eureka	99.5	99.5	95	900
	Mammoth	97	97.6	94	4455
	Pan-American	97.5	98.2	91	4145
Corn	Early Mastodon	90	99.03	86	....
	Flint	98	99.14	99.5	....
Millet	Hungarian	98	99.84	73.5	2680
	Hungarian	97	99.89	60	1800
	Japanese	97	95.16	75.5	7665
	Japanese	91	94.4	45	10370
	Japanese	95	94.56	26	12485
Timothy	Gold Medal	99.7	99.77	88.5	....
	Gold Medal	98.7	99.41	87.5	....
	Gold Medal	99.6	99.64	86	630
	Green Mountain	99.5	99.5	87	1890
	Herald	96	96.02	86	2910
	Imperator	99	99.15	75	1125
	Pan-American	99.5	99.37	90	370
Buckwheat	Japanese	99	99	98	160
	Japanese	98	99.59	95	55
Bluegrass	Kentucky	85	86	*	16880
Grass	Orchard†	75	93.8	*	1905
Rape	————	98	99.4	98	....
Rye	Spring	98	97.33	87	15
Sweet Clover	————	97	99.2	88	90
	————	98	99.55	88	....
Wheat	————	98.6	98.95	96.5	15

*Not determined. †Not orchard grass but awnless brome grass.

M. G. WILLIAMS, PUTNEY, VT.

Alsike Clover	————	....	96.14	77.5	4347
Redtop	————		83.34	74	*158468

The following statements have reference to the corresponding letters in the tabular matter on pages 19 to 50.

A. Wholesaler, A. B. Lyman, Excelsior, Minn. Sold by L. L. Marsh, Enosburg Falls, also by Hatch Hardware Co., St. Albans. Mr. Marsh held a statement from the wholesaler to the effect that the goods were "genuine Grimm alfalfa" which he (Marsh) supposed was the guaranty required by the law. He sold to other parties for further selling, furnishing a copy of this statement.

B. E. W. Bailey & Co., Montpelier, state that because of carelessness on the part of certain employees several shipments of seed, more especially corn, were sent out untagged as to their purity and promise that they will see to it that no such lapse occurs again. One retailer, J. E. Foster of Underhill, took steps to secure a proper guaranty before he made sales.

C. Oversight on the part of the wholesaler whose record has been as a whole good in the matter of guaranty making.

D. The retailer, H. H. Cushman, of Rochester, states that he turned the seed into barrels and inadvertently did not mark them and that he would see to it that all future sales were properly marked. He states that the red clover goods were guaranteed 99.75.

E. The retailer, P. D. Pike and Son, of Stowe, states that these goods represented three small lots carried over from 1915, being in each case a broken bag; that they were not offered for sale after the lack of guaranty was called to their attention; and that, since they were not guaranteed, the residue would be used by the members of the firm personally. No claim was made, however, that sales had not been made prior to the date of sampling.

F. Private purchases. This fact does not exempt the wholesaler from the necessity of making guaranty under the state law, but relieves the local people of liability.

G. Joseph Breck and Sons Corporation state that through oversight purity guaranty statements were not placed on all packages shipped into Vermont. They furnish an affidavit concerning one of their Vermont shipments in which the purity guaranty is stated to be 97% and in which they claim that "to the best of (their) knowledge and belief (the shipments) were not misbranded" and that they "complied with the regulations of the pure seed law of the state of Vermont." This affidavit is a somewhat peculiar one. It omits to state that the goods were not guarantied, an omission which by the very term of the law constitutes "misbranding."

H. The retailer does not answer letters, paid no attention to the citation to the hearing and furnished no guaranty statement. The wholesaler presumably furnished a guaranty statement to the retailer as he is scrupulously careful in this respect.

K. E. A. Mosier of Berkshire, doing business under the name of the Michigan Seed Co., of Richford, Vt., states under oath concerning his sundry sales found on sale unguaranteed that "said corn was not misbranded, in fact it was not branded at all, but the seed was good, clean seed and was not adulterated, and he verily believes that the seed was of such a standard as our statutes require." This is an interesting statement in two respects. First, that it is claimed that "said corn was not misbranded" whereas the law states that "seed shall be deemed to be misbranded * * * if it fails to carry the guaranty required by section 2 of this act." Second, that it is "believ(ed) that the seed (is) of such standard as our statutes require," whereas the statutes establish no standard. However, it substantiates the claim made by the Station, namely, that unguaranteed goods were sold.

L. The wholesalers, The Page Seed Co., of Greene, N. Y., state in correspondence with their retail representative that they "intended to put special tags on each bag of seed that went into Vermont" and that if such were not affixed to the bags "it was an oversight or else they were lost in transit." They furnished on May 23 a guaranty statement of 99 percent purity.

M. The wholesalers, The Page Seed Co., of Greene, N. Y., paid no attention to the citation to hearing. The retailer acknowledged that they had offered unguaranteed goods for sale, and, after some time submitted samples for analysis, but without the fees required by law; consequently they were not tested. In this connection see note L.

N. The wholesalers, the J. B. Rice Co., of Cambridge, N. Y., make no guaranties. Vermont purveyors of Rice goods should see to it that they

themselves furnish the guaranties required by law, as some have done each year.

P. The wholesalers, the Ross Bros. Co., of Worcester, Mass., claim that these goods were shipped by them to the Cutler Co., of North Wilbraham, Mass., and by the latter transhipped into Vermont. There being no seed law in Massachusetts, the Ross Bros. Co., consider themselves exonerated, since their sale to Massachusetts parties was legal under Massachusetts laws; and the Station agrees with them in their contention. The Vermont retailer paid no attention to correspondence, or to the citation to hearing.

Q. Neither wholesaler nor retailer answer letters, pay attention to citation to hearings or furnish guaranties.

R. The wholesaler, the Stanford Seed Co., Inc., state that they furnished a guaranty with each shipment on each bag. They have submitted carbon copies of some of their invoices in cases where no guaranties are reported on which appear the following: "Note. If tags are lost in transit please make out new ones in accordance with the above and attach to the goods on arrival." There seems no reason to blame the wholesaler in these cases.

S. Guaranty furnished late in May by the wholesaler, T. W. Emerson, and attached by the retailer. The Station does not know what figure was supplied.

T. The wholesaler, T. W. Emerson of Boston, does not answer letters nor did he pay attention to citation of hearing. The goods were bought in 1915 and retailer failed to observe omission of guaranty statement.

U. Many Vermont purveyors of seed, more especially the mill men and sellers of commercial feeding stuffs, offer so-called "recleaned, unsulphured oats" without the guaranty statement required by section 2 of the seed law. They claim that they do not offer "seed oats" but "oats"; that they do not know what they are bought for, or what they are used for, neither are they interested in the disposition which the buyer makes of his purchase; that while doubtless many buyers do use them for seed, some feed them to fancy stock, etc.; that they themselves buy the oats not from seed houses but from western millers or through eastern jobbers, who will not furnish purity guaranties; that being sold in bulk they are inevitably more or less uneven in character, sufficiently so, so that they cannot be guaranteed; that the impurities tend to settle to the bottom of the car, thus inducing a stratification of the shipment and making it of uneven grade one part as compared with another; that in the rush of the season, with delayed shipments arriving just when seeding must be done, neither they nor the farmers can afford to wait while samples are taken, shipped to the Station, analyzed—with necessary delays there on account of multitudinous samples arriving within a short time—and delayed analytical results returned; that to be forced to go through with this procedure would not only involve extra expense to them, but would increase the cost of the oats to the farmer; that this type of oats is sold at a much lower price than are the regular "seed oats"; and that if any barrier is interposed which would serve to hinder this trade, it would be contrary to the best interests of the farming community.

The Attorney General was asked whether oats sold in the manner specified were "oats * * * which are to be used for sowing or seeding purposes" within the meaning of the statute and he states that "the dealer cannot be held to be familiar with the intent of every purchaser, unless such intent is stated at the time of purchase. A customer buying oats in bulk may intend to feed the same and unless, as I have said, the intent of the purchaser to use the same for planting only is conveyed to the dealer, or the dealer is offering the oats as 'agricultural seed,' he is not bound to follow the provisions of section two of the Act." Hence the sales of the goods represented by the notation U on pages 31 and 32 was legal, the absence of a guaranty to the contrary notwithstanding.

V. The Nungesser-Dickinson Seed Company claim for the shipments made to B. F. Wheldon's Sons of Ludlow of alfalfa and red clover that "the purities were not given by us when offering the seed." The figures as printed in the tables were found by the sampling agents attached to the goods as they were being offered for sale.

W. The Edward F. Dibble Company state that they "do not give any guaranty whatever as to the purity of Japanese millet or red top." The sampling agent reports finding 99.5 percent guaranties on the goods as

offered by the retail dealer. This may have been a sampler's error or the retailer may have placed this guaranty statement on these goods without warrant from the wholesaler.

X. The Amendt Milling Company protests that these goods were not sold by them as seed oats, and that their name should not be connected with the sale; that "any time (they) offer seed corn (they) will be careful to have analysis made of it before shipment." This statement, taken in connection with that of the local dealer, thoroughly absolves the Amendt people from liability under the law, and the loophole in the law as set forth in note U absolves the local dealer; but the Station, having found the goods on sale with the Amendt Milling Company label on it, looks upon the Amendt people as wholesalers and consequently so lists that company in its tables.

Y. The Charles M. Cox Company do not sell seed oats as such. They sell by sample and say that "if the dealers desire the sell these oats as 'seed oats' it is something entirely beyond our control" and that consequently their name should not be connected with the sale. This statement, taken in connection with that of the local dealer, thoroughly absolves the Cox people from liability under the law; and the loophole in the law, as disclosed by the opinion of the Attorney General (see note U), absolves the local dealer. But the Station, having found the goods on sale with the Cox label thereon, looks upon that company as the wholesaler as defined by the law and consequently so lists it.

VII. THREE YEARS OF SEED INSPECTION

Neither a fertilizer analysis nor a seed analysis can be made before samples are taken; and samples cannot be drawn before the goods are placed on sale in Vermont; and the goods are not placed on sale until a short time before the season of their use arrives. Hence it is that analyses never have been and never can be made and published in time for use during the season in which the goods are used. But the records of former years are of service in this juncture.

It has been customary at this Station for several years to publish in the annual fertilizer bulletin a statement of guaranty maintenance covering a period from three to five years. Thus a buyer who contemplates buying a brand manufactured by the Blank Fertilizer Company of Blankville, N. Y. can tell at a glance whether or not the brands made by this company had been in previous years as good as they were said to be and from past performance can reason as to future probabilities. The present issue is the third seed inspection bulletin; and it is now possible to institute similar comparisons between promise and fulfillment with this commodity.

It is freely admitted that the facts cannot be set forth in quite as clear cut a fashion as is the case of fertilizers. A fertilizer is a manufactured product made of definite materials, compounded and processed under close factory supervision, its component parts so intimately commingled that the likelihood of appreciable stratification and separation is slight. An agricultural seed, however, is a natural product, and, though often subjected to a cleansing process in order to remove weed seed, is not, unless of extremely high grade, as homogeneous a product as is a fertilizer. The variation between different samples drawn from the same lot is necessarily greater than that properly to be found between fertilizer samples similarly taken.

Then, too, the fertilizer trade has been thus controlled for a generation. Every state in which fertilizers are sold has inspection laws. The trade has adjusted itself long ago; it has gotten over all its peevishness and pouting; it has learned that adequate inspection and publicity are a help and not a hindrance to legitimate business. Not so, however, with the seed trade. Seed laws exist in only about a dozen states; some seed houses protest that they cannot, others that they will not, guarantee their products; state laws do not run beyond state boundaries; and the trade as a whole has not yet caught the vision of the possibilities latent in the inspection service. History is repeating itself in this respect, and the attitude of the seed trade of today toward in-

spection is that of the fertilizer trade of the seventies. It is a situation which time will cure.

It is on these accounts that, for the present at any rate, very wide —perhaps absurdly wide—tolerance limits have been allowed in the subjoined tables. It is safe to say, however, that any lot listed in the right hand column was a long way short of guaranty.

This table does not tell the whole story. The sellers who did not guarantee their goods do not figure in it; the brands found in but one of three inspections and the many unnamed brands are left out. Its only mission is to afford the farmer a quick and ready means of determining the facts as to failure to make good guaranty statements in the brands more commonly found on sale under definite brand names. The illicits, the unnamed, the orphans, those for which their purveyors do not stand sponser by name or promise, those offered by retailers who had forgotten brand names or destroyed the tags, do not appear. It is consequently a much less satisfactory presentation than can be made in the fertilizer bulletins and is indicative of the less standardized conditions now existing in the seed trade.

It should not be forgotten, furthermore, that the maintenance of guaranty does not tell the whole story. The state law sets no standard. A seller may place any figure he sees fit upon his product, 99 percent or 2 percent as he pleases. This table tells nothing as to the quality of the goods; it simply sets forth the validity of the seller's promises.

The results are shown alphabetically by wholesalers' names and alphabetically by seed and by brand name. They cover the inspections of 1914, 1915 and 1916. The differing guaranties within a brand indicate the extremes found during the three seasons used in connection with the brand names. Corn and millet are sold under varietal and not brand names, e. g., Sanford, Leaming, Longfellow corn, and German, Hungarian and Japanese millet. Everybody, for example, sells Sanford corn; only one house sells "White Mountain" seed. Guaranties are very erratic, especially with corn.

It should finally be said that the Station cannot be as certain of the accuracy of guaranty statements as printed in this bulletin as it is in the case of commercial fertilizers. The statements of sampling agents cannot be checked up as readily—indeed, often they cannot be checked at all. Fertilizer guaranties are definite and unvarying, one lot as compared with another. A 1916 guaranty of Bowker's Hill and Drill Phosphate, for example, is one and the same thing on each and every one of the thousands of bags sold in Vermont. But the guar-

anties of the agricultural seed brands vary not only in one year as compared with another, but in one lot as compared with another during the same year. And very properly; for while a fertilizer brand is a fairly standardized product a seed brand cannot be so much so. Thus we find in this year's inspection the following guaranties on the precise same brands of the same sort of seed (timothy) sold by the same wholesalers: 99 and 99.8; 99 and 99.5; 99.33 and 99.75; 98.7 and 99.7. This does not mean carelessness on the part of the wholesaler but care; care that to each lot of a necessarily variable product its proper due is accorded. But it is proof positive of the need of state regulation. Furthermore, this situation clearly indicates how little a brand name means, but how important is a guaranty.

During normal years, when war's alarms do not send the price of acid phosphate toward the skies and when potassium is not a rare element, the composition of a well made standard fertilizer, such a one as that just cited, is almost as constant and unvarying one year as compared with another as is the North Star. On the contrary, a red clover seed sold, let us say, under the "Red King" brand, may be clean in 1915 and weedy in 1916; a lot sold in Rutland this spring may have been of high grade, whereas another lot sold in the adjoining town of Proctor is foul as perdition; yet if correctly guarantied in each case, the sales are legal. The seed trade is not standardized; perhaps it cannot be. Consequently buyers should watch guaranties full more than brand names.

THREE YEARS' RECORDS

Seed	Brand name	Purity guaranties range from — to —	Total number of samples analyzed which were reported to be guaranteed	Number of samples found within 2 percent of guaranty	Number of samples 2 percent or more below guaranty
E. W. BAILEY & CO., MAIN ST., MONTPELIER, VT.					
Clover, alsike	Ace	93.7 -99.5	4	4	..
Clover, red	Ace	98 -98.5	3	2	1
Corn	———	90 -99.6	5	5	..
Timothy	Globe	99.7 -99.8	3	3	..
BARBER & BENNETT, ARCH AND CHURCH STS., ALBANY, N. Y.					
Timothy	Bison	98 -98.4	3	3	..
JOSEPH BRECK & SONS CORPORATION, 51-52 NORTH MARKET ST., BOSTON, MASS.					
Corn	———	98 -99	5	5	..
Millet, Japanese	———	96.8 -98	2	2	..
CHAMPLAIN SEED CO., 191 BANK ST., BURLINGTON, VT.					
Corn	———	95 -99.95	12	9	3
E. W. CONKLIN & SON, 28-48 MONTGOMERY ST., BINGHAMTON, N. Y.					
Alfalfa	IXL	99.3	2	2	..
Barley	Six Row	98 -98.8	3	2	1
Clover, red	Crown	99.25-99.35	5	5	..
	Etna	92.8 -93.7	2	2	..
Corn	———	98.28-99.26	6	6	..
Millet	———	96.4 -99.5	8	6	2
Oats	Northern Wonder.	96.38-99.5	3	3	..
Timothy	Acme	99.8	3	3	..
	Bingo	99.95	3	3	..
	Don	96 -97.55	2	2	..
	King	99.6	2	2	..
	Rex	98.4	3	3	..
A. DICKINSON CO., CHICAGO, ILL.					
Alfalfa	Ace	99.3 -99.7	3	3	..
	Pinetree	99.5	4	4	..
Barley	Six Row	98 -99.4	3	3	..
Clover, alsike	Ace	93.7 -95	6	6	..
	Globe	97 -98	3	3	..
	Kaiser	87.8 -92	5	5	..
	Queen	87 -88	3	3	..
Clover, red	Ace	98 -99.7	6	6	..
	Globe	99 -99.6	5	5	..
	Kaiser	97	3	3	..
	Queen	91.4 -96	6	6	..
Corn	———	98 -99	6	6	..
Millet	———	93 -99.5	23	22	1

THREE YEARS' RECORDS (CONTINUED)

Seed	Brand name	Purity guaranties range from — to —	Total number of samples analyzed which were reported to be guaranteed	Number of samples found within 2 percent of guaranty	Number of samples 2 percent or more below guaranty
A. DICKINSON CO., CHICAGO, ILL. (CONTINUED)					
Timothy	Bison	97.5 -98	5	5	..
	Colonial	98.5 -98.6	3	3	..
	Globe	99 -99.8	4	4	..
	Pinetree	99 -99.5	3	3	..
HOLBROOK GROCERY CO., KEENE, N. H.					
Alfalfa	White Mountain	99.5	2	2	..
Clover, alsike	White Mountain	98 -98.5	4	4	..
	X	70	2	2	..
	XX	75 -80	2	2	..
	XXX	87 -90	4	4	..
Clover, red	Ace	96.8 -98	3	3	..
	White Mountain	?	4	4	..
	XX	85 -90	4	4	..
	XXX	96.5	3	3	..
Corn	———	85 -99	4	4	..
Millet	———	89 -98	17	17	..
Oats	White Mountain	99	4	4	..
Redtop	White Mountain	86 -95	2	2	..
Timothy	Monadnock	99.5	4	4	..
	Pinetree	99.5 -99.7	2	2	..
	White Mountain	99.5 99.7	6	6	..
	X	93	2	2	..
	XX	96 -98.5	2	2	..
	XXX	98.5	3	3	..
	———	.....	2	2	..
J. O. MIDDLEBROOK & SONS, COLLEGE ST., BURLINGTON, VT.					
Corn	———	94 -95	10	10	..
W. H. MOREHOUSE & CO., 46-47 PRODUCE EXCHANGE, TOLEDO, OHIO.					
Barley	Six Row	98.9 -99.5	2	1	1
Clover, alsike	Anchor	99.5	2	2	..
	Bell	97 99.25	3	2	1
Clover, red	Bell	99.5	2	2	..
Corn	———	95 -99.5	14	11	3
Oats	Silver	95 -98	2	2	..
Timothy	Anchor	99.33-99.75	3	3	..
PAGE SEED CO., GREENE, N. Y.					
Corn	———	90 -99	9	9	..
JEROME B. RICE SEED CO., CAMBRIDGE, N. Y.					
Corn	———	90 -99.09	9	8	1*

*This guaranty was not furnished by the wholesaler but by the local dealer.

THREE YEARS' RECORDS (CONTINUED)

Seed	Brand name	Purity guaranties range from — to —	Total number of samples analyzed which were reported to be guaranteed	Number of samples found within 2 percent of guaranty	Number of samples 2 percent or more below guaranty
W. H. SMALL & CO., EVANSVILLE, IND.					
Alfalfa	Eclipse	98 -98.5	3	3	..
Clover, alsike	Eclipse	92.77-97.5	4	3	1
Clover, red	Climax	.....	..	..	..
	Superfine	99	4	4	..
	Eclipse	98 -98.5	4	4	..
Millet	———	98 -99	3	2	1
Timothy	Climax	99	3	2	..
	Eclipse	98	2	2	..
STANFORD SEED CO., BUFFALO, N. Y.					
Alfalfa	Empire	99.5	3	3	..
Barley	Six Row	90	2	2	..
Clover, alsike	Arc	95.8 -98.5	7	7	..
	Fancy	95.84-97.29	5	5	..
	Reliable	96.65-97.5	4	4	..
Clover, red	Arc	97 -99.48	15	15	..
	Honor	99.25-99.7	3	3	..
	Reliable	97.07-99.6	4	4	..
Corn	———	90 -99	52	52	..
Millet	———	85 -98.39	20	20	..
Timothy	Dandy	99	2	2	..
	Honor	99.7	3	3	..
	Liberty	99.2 -99.5	3	3	..
	Prime	99	3	3	..
J. B. VARICK, MANCHESTER, N. H.					
Timothy	Durham	99.5	2	2	..
WHITNEY-ECKSTEIN CO., BUFFALO, N. Y.					
Clover, alsike	Eureka	98 -99	4	4	..
	Export Fancy	97 -98.5	3	3	..
	Pan-American	96 -97	4	4	..
Clover, red	?	97.5 -98.5	2	2	..
	Pan-American	98.6 -99.5	6	6	..
Corn	———	.....	7	7	..
Millet	———	91 -98	12	12	..
Timothy	Gold Medal	98.7 -99.7	6	6	..
	Green Mountain	99.5	..	..	..
	Herald	96 -98	2	2	..
	Pan-American	99.5	3	3	..

VIII. CONCERNING WEEDS AND WEED SEED

WHEN IS A PLANT A WEED?

When we seed a field we usually want to grow only one kind of plant and the seed of any other plant which may be sown will produce weeds. Most of our crops should be raised in "pure culture," that is to say we should not grow oats in wheat fields, barley in oat fields, ragweeds in corn fields, etc. This should be especially true of areas which are producing crops which will be used for seed. There are associated usually with the crop-plants many undesirable varieties—weeds—which resemble the crop-plants so much in manner of growth, especially in time of seeding, that their seeds commonly are found in those of our crop-plants (table, page 64). Dealers of agricultural seed usually try to reduce this weed seed content before placing their wares upon the market. The tables of analyses on pages 19 to 50 show the degree of success to which they attain.

Some of the more striking characteristics which enable weeds to grow in spite of the efforts to kill them are shown below. Any attempt to destroy them must be based on a thorough knowledge of these characteristics.

1. A single plant sometimes will produce enormous numbers of weed seeds.

2. Many weed seeds show great viability, living 30 years or more in the soil.

3. Some weed plants ripen and scatter their seed before the crop matures, and others when the crop becomes ripe and is harvested, often being harvested with it.

4. Some weed seeds are difficult to separate from the seed of the crop with which they are grown.

5. Some weed seeds are so small and the seed of some weed plants is so inconspicuous as to escape notice.

6. Some weed plants break from the soil and become tumble weeds and at times travel long distances—sometimes over the snow; others are furnished with a parachute or sail, which enables them to travel with the wind; while others are furnished with grappling hooks wherewith to fasten upon passing animals.

There are many channels for the introduction of weeds—in certain feeding stuffs, in city manure, in box packing; they come in by way of the railroad, the threshing machine and other farm mechanisms; they are bought and paid for in agricultural seed. Not only are their

numbers multiplied, but the species have increased. It is quite safe to say that within the last 50 years the numbers of weed plants in Vermont have increased manifold, and the number of species has at least doubled and probably trebled.

HOW CAN A FARMER BEST FIGHT WEEDS?

1. He should know his enemies. He should learn how they look. He should discover their habits. He should know what remedial treatments to apply. He should realize that methods which will work with annuals like pigweed will not work with biennials like the bull thistle or with perennials like quack grass or Canada thistle.

2. He should know what weed seeds look like in order that he may do what he can to keep them out. In view of the fact that agricultural seed is perhaps the most important means whereby weeds are introduced upon a farm, it is particularly important that he carefully scrutinize his seed purchases, buying only those brands which bear a high purity guaranty. To the end that Vermont seed buyers may know what the weed seeds look like, the illustrations in this bulletin upon pages 65 to 80 have been printed, with such clear descriptions as will enable a farmer, if he desires, to recognize the more common kinds. With the aid of a small reading glass one can quite commonly determine, after a little practice, what is what.

3. He should scrutinize carefully his feeding stuff purchases, especially if he buys either wheat feeds (brans, middlings, mixed feed, reddog) or proprietary dairy, stock and horse feeds.

The word "screenings" or "grain screenings," often found on the packages of these feeding stuffs, mean no more or no less than simply "weed seeds." Federal laws compel the flouring mill people to state the facts on every package of wheat offals which enter into interstate commerce and which contain grain screenings. The phraseology in such cases is usually "with ground screenings not exceeding the mill-run." It may be fairly assumed that wheat mill by-products which do not carry a statement as to their screenings content as a matter of fact are practically free from admixture with this by-product of the manufacture of flour. Certain proprietary stock feeds contain grain screenings. The state law requires a statement to that effect in case they are used. It is quite common with these feeding stuffs for the manufacturers to grind the screenings; and sometimes they are kiln dried. This procedure naturally lessens the likelihood of future trouble, but it should be remembered that many weed seeds are extremely small

and are apt to escape grinding, and that some of them are so hard shelled as perhaps to escape death in the kiln. In view of the fact that there are plenty of satisfactory feeding stuffs on our markets at prices no higher than those asked for goods containing this particular by-product, it would seem wise to urge the purchase of goods not thus laden. The current feeding stuff bulletin (No. 197) tells the story completely and compactly. In this connection it may be well to recall the feeding trial made in 1906 and reported upon in bulletin 138 wherein by word and picture was clearly set forth the fact that weed seeds survive passage through the bovine alimentary canal.

4. He should see to it that the threshing machine and similar mechanisms are clean before they are used upon the farm.

5. He should strive to prevent weeds from ripening their seed, especially late in the season.

6. He should so plan his rotations as to make the killing of weeds an important item, using cultivated crops for this purpose.

7. He should in some cases use smother crops—quick growing, heavily seeded crops such as rye, buckwheat and clover.

8. He should keep the land occupied, crop covered throughout the growing season.

9. He should clean up fence rows, along the highways, etc.

10. He should spray oat fields with a solution of iron sulphate (75 pounds in 50 gallons of water) to kill kale.

11. He should protect birds which eat weed seeds.

12. He should plow in the fall, thus stirring up the ground and causing seed to germinate.

13. He should keep everlastingly at it, by machine labor if possible, by hand labor if necessary.

There is no royal road to weed killing. A weed infested farm cannot be made weed free except at considerable expense. However, it is for each farmer to say whether or not he will enlist in this fight.

THE WEED SEED CONTENTS OF AGRICULTURAL SEED

Four studies have been made at this Station of the nature of the weed seed contents of the agricultural seed sold in Vermont; in 1898, 1900, 1908 and during the present year. As a result the following tabular statement is offered setting forth in a general way the weed seed inhabitants of our commonly sold seed supplies. The table serves a double purpose. One may readily determine by following down a perpendicular column what sort of weed seed appear to be commonly

and what occasionally found in each kind of seed as sold in our Vermont markets. And one who wishes to know what kinds of agricultural seed are apt to contribute to the spread of a given weed—five-finger, for instance—can find out the facts by following the appropriate horizontal line.

The letter C means that the weed seed in question is found commonly and usually in considerable quantities; the letter O that it is found occasionally, sometimes in considerable, often in smaller, quantities.

It should be understood of course that a table of this kind is suggestive only. Any of these weed seeds and many others may occur in a given sample of any sort of seed. It simply indicates probabilities based on past analytical experience with the Vermont seed trade. It should be said in this connection that alfalfa, barley and oats are not often very weedy; that alsike clover is apt to be quite free from but sometimes is heavily loaded with weed seed; that red clover once our foulest seed, a reputation still borne out by some lots, often is found to be very clean; that millet is usually a fairly clean seed; that redtop is by far our weediest agricultural seed for the reason that its chaffy nature makes it hard to clean; and that timothy is apt to carry many sort but relatively small numbers of weed seed.

THE COMMON WEED SEEDS FOUND IN AGRICULTURAL SEED

	Alfalfa	Barley	Alsike clover	Red clover	Millet	Oats	Redtop	Timothy
Amaranth	..	..	..	C	..	..	..	C
Black bindweed	..	O	..	..	C	O	..	..
Black medic	..	..	O	O	..	..	..	..
Blue vervain	..	..	..	O	..	..	..	C
Burdock	..	..	..	O	..	..	..	..
Canada thistle	..	..	O	..	..	..	..	..
Catchfly, night flowering	..	..	C	C	..	..	..	..
Chess	..	..	..	..	O	..	..	..
Chickweed	..	..	O	..	..	..	C	O
Cockle	..	..	..	..	..	O	..	..
Crabgrasses	..	..	C	C	C	..	..	C
Docks	..	..	C	C	..	..	..	C
Dodder	..	..	..	..	..	..	C	..
Ergot	..	..	..	..	..	..	C	O
Evening primrose	..	..	O	..	..	..	..	C
Five-finger	..	..	C	O	..	..	C	C
Green foxtail	O	..	C	C	C	..	..	C
Kale	..	..	..	O	C	O	..	..
Lady's thumb	..	..	..	C	C	O	..	..
Mayweed	..	..	C	O	..	..	..	C
Old witch grass	..	..	C	O	..	..	..	O

THE COMMON WEED SEEDS FOUND IN AGRICULTURAL SEED (CONTINUED)

	Alfalfa	Barley	Alsike clover	Red clover	Millet	Oats	Redtop	Timothy
Papsalum	..	..	..	O	..	..	..	..
Peppergrass	..	..	C	O	..	..	C	C
Pigweed	O	..	C	C	C	O	..	C
Plantain, bracted	..	..	C	C	..	..	..	..
" common	O	..	C	C	..	..	C	C
" lance-leaved	..	..	C	C	..	..	C	C
" Rugel's	..	..	C	C	..	..	C	C
Ragweed	..	O	..	..	C	..	..	..
Sheep sorrel	..	..	C	C	C	..	..	C
Smartweed	..	O	..	C	C	..	..	..
Spurge	..	..	..	C	..	..	..	..
Vetch	..	O	..	..	..	O	..	..
Wild climbing buckwheat.	..	..	..	..	..	O	..	..
Wild carrot	..	..	..	C	..	..	..	..
Wild oats	..	O	..	..	..	O	..	..
Yarrow	..	..	..	..	..	..	C	O
Yellow daisy	..	..	..	..	..	..	..	C
Yellow foxtail	..	O	O	C	C	O	..	C

C—Commonly found and usually in considerable quantities.
O—Occasionally found, sometimes in considerable, often in small quantities.

The following pictures and descriptions are presented at this time as pertinent to the conduct of an adequate seed inspection. The worst feature in seed impurities is the weed seed content of a seed supply. In proportion as farmers become familiar with the appearance of a weed seed, they should be the better enabled to detect its presence in a contemplated purchase. The pictures are so accurate and the descriptions of the seed illuminating that it is believed that by their use the everyday farmer may, if he will, readily make himself familiar with and repel the invasion of many of his weed enemies.

The Station is indebted to the courtesy of the Michigan Station for the loan of most of the cuts, which are the product of the facile pencil of Mr. F. H. Hillman, now of the Federal Department of Agriculture. The smaller views show the size, the larger, from several points of view, the magnified appearance of the seed. In several cases cross sections are indicated. Common names are stated in CAPITALS, scientific names in *italics*. By reference to the above table one can tell whether or not a given weed seems to occur commonly in our seed offerings. Cuts of alfalfa, clover, etc., seed are also included.

Several of the weed seeds illustrated are not often found in large numbers in our agricultural seed, but represent, notwithstanding, some of our serious weed pests; and a few of the seeds found more or less frequently in our seed trade are not illustrated.

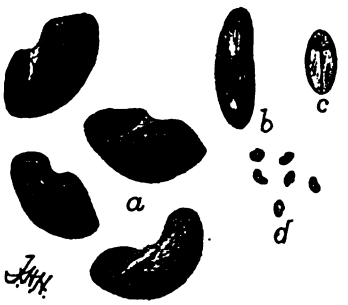

Fig. 1.

ALFALFA. LUCERNE. *Medicago sativa* L. A well-known forage plant closely related to the clovers. Flowers bluish purple in long cylindrical heads.

Seeds yellow green to light brown, smooth, kidney-shaped, somewhat angular, varying greatly in size and shape.

BARNYARD GRASS. *Echinochloa crus-galli* (L.) Beauv. One of our stoutest and tallest grasses; found everywhere in gardens and waste places. In appearance it resembles the cultivated Japanese millet which is a close relative.

Grains ⅛ inch long, shiny, inner side flat, outer side convex, covered by a thin, loose outer husk.

Fig. 2.

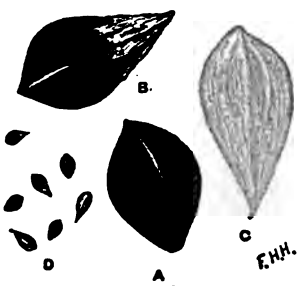

Fig. 3.

BINDWEED, BLACK. WILD BUCKWHEAT. *Polygonum convolvulus* L. A twining, annual vine with rather rough branching stems and thin, smooth arrow-head-shaped leaves.

Fruit ⅛ inch long, triangular, dull black and bluntly pointed. Found commonly in grain and clover seed.

BINDWEED, FIELD. *Convolvulus arvensis* L. A deep rooted, climbing, perennial vine, having large pink flowers, smooth triangular leaves. Becoming common in Vermont.

Seeds ⅛ inch in diameter, dark brown, pear-shaped, one side rounded, the other angular.

Fig. 4.

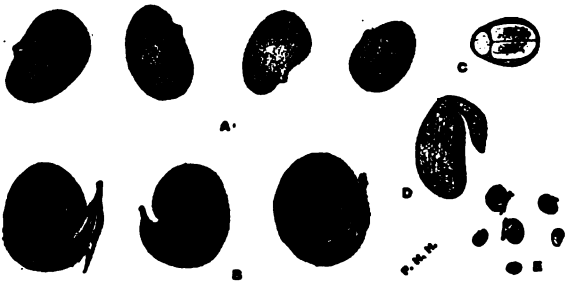

Fig. 5.

BLACK MEDICK. NONESUCH. *Medicago lupulina* L. A common annual weed in clover fields. Plants slender and partly creeping, trifoliolate, yellow flowers in small heads. The seed pods become black when ripe.

Seeds yellowish green, smooth, egg-shaped, flattened, with a slanting protuberance on the inner side.

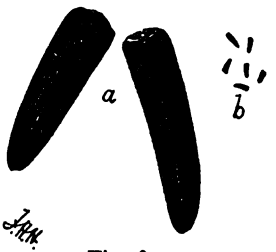

Fig. 6.

BLACK-EYED SUSAN, YELLOW DAISY. *Rudbeckia hirta* L. A tall, slender weed, 1 to 3 feet high, common in pastures and meadows, flower heads yellow with a dark center. Often confused with the OX-eye daisy.

Seeds brown to black, elongated, 4-angled, ⅛ inch long, ridged lengthwise, cut off square at the top.

BLADDER CAMPION. *Silene latifolia* (Mill.) Britton & Randle. A perennial, tufted weed, ½ to 2 feet high with white, drooping flowers in a spreading inflorescence. Fruit bladder-like.

Seeds dark, grayish brown, wedge-shaped to kidney-shaped, roughened by fine rows of short teeth.

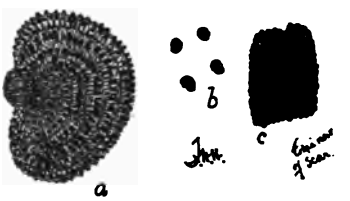

Fig. 7.

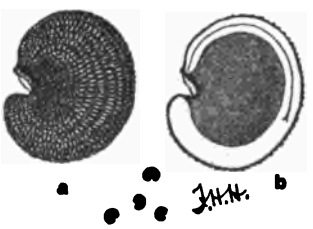

Fig. 8.

BOUNCING BET. SOAPWORT. *Saponaria officinalis* L. A perennial, tufted weed 1 to 2 feet high, with pink flower and opposite leaves. Common around dwelling places.

Seeds rough, dull black to slate-color, shortened kidney-shaped with a notch on one side.

CARROT, WILD. *Daucus carota* L. A common and persistent weed growing in almost any soil. Its clusters of white flowers are seen almost everywhere in late summer and autumn. Stems slender, branching, ending in a long stem bearing a cluster of white flowers.

Seeds light brown, formed in pairs, boat-shaped, four light ridges along the curved side bearing weak spines.

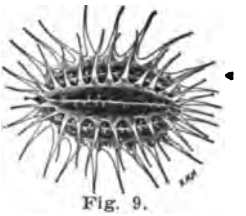

Fig. 9.

CATCHFLY. See NIGHT-FLOWERING CATCHFLY (35).

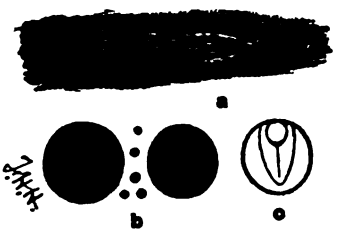

Fig. 10.

CHARLOCK. *Brassica arvensis* (L.) Ktze. The common annual mustard of Vermont. Erect branching plants 1 to 3 feet high, flowers bright yellow, seeds in constricted pods 1 to 2 inches long.

Seeds spherical, dark reddish brown, delicately pitted.

CHICORY. *Chichorium intybus* L. A much-branched, deep-rooted perennial, common along Vermont roadsides. Stems woody, round, hollow, flowers blue, strap-shaped, borne in heads along the stems.

Seeds brown, prism-shaped, 4 to 5 ribbed, crowned with a double row of pointed scales.

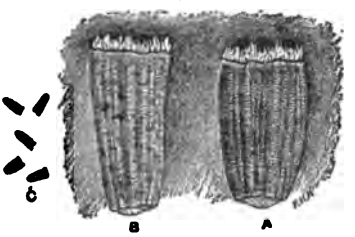

Fig. 11.

Fig. 12.

CHICKWEED. *Stellaria media* (L.) Cyrill. A tufted, slender, many-branched, creeping or ascending annual with opposite leaves and numerous small, white flowers.

Seeds numerous, small, yellowish-brown, flattened, nearly round with a notch on one side, roughened by fine rows of short teeth.

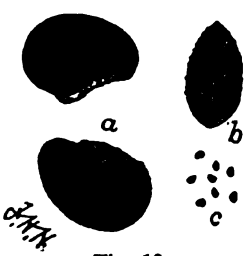

Fig. 13.

CINQUEFOIL, COMMON. *Potentilla canadensis* L. A tufted, spreading perennial growing commonly in meadows, having strawberry-like runners, golden yellow flower on a long slender stalk. Leaves in five parts.

Seeds mostly brown, almost egg-shaped, slightly flattened, more or less ridged.

Fig. 14.

CLOVER, ALSIKE. *Trifolium hybridum* L. A clover having characters intermediate between the red clover and the white clover. Stems erect, leaves not marked.

Seeds light green to dark green, smooth, rounded at one end and cut almost squarely off at the other, $^1/_{18}$ inch in diameter.

CLOVER, RED. *Trifolium pratense* L. The coarsest and tallest of our common clovers. Flower clusters almost spherical, leaves marked by a dark center.

Seeds yellow to purple, smooth, dull, flattened, irregular kidney-shaped, the one end narrower than the other, a groove extending from the scar towards the broader end, $^1/_{14}$ inch in diameter.

Fig. 15.

Fig. 16.

CLOVER, WHITE SWEET. *Melilotus alba* Desr. A stout, much-branched perennial, 3 to 6 feet high, common along roadsides. Flowers bluish purple in long cylindrical heads.

Seeds yellowish brown, smooth, elliptical, the scar towards the end.

COCKLE. See CORN COCKLE (17).

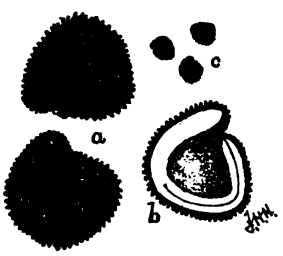

Fig. 17

CORN COCKLE. *Agrostemma githago* L. A winter annual 1 to 3 feet high found commonly in grain fields. Stems erect and only slightly branched above, leaves narrow, flowers purple.

Seeds about ⅛ inch in diameter, pitchy black, somewhat flattened, rounded triangular, the thin edge notched, covered with curved rows of short teeth. Seeds poisonous.

COWBANE. See HEMLOCK, WATER (30).

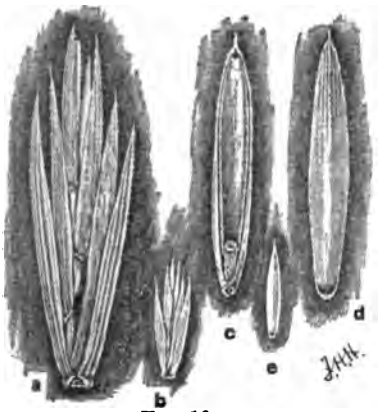

Fig. 18.

COUCH GRASS. QUACK GRASS. TWITCH GRASS. WITCH GRASS. *Agropyron repens* (L.) Beauv. One of our worst weeds. Grows abundantly on poorly cultivated land. Its spreading rootstocks and couching habit distinguish it from most Vermont grasses.

Grains in a hard, smooth husk about ⅜ of an inch long; slender, with a short awn at the tip, their outer side convex, their inner side concaved.

Fig. 19.

CRAB-GRASS, LARGE. FINGER GRASS. *Digitaria sanguinalis* (L.) Scop. A very persistent annual weed found in most gardens and cultivated fields. The resemblance of its inflorescence to the outstretched fingers of a hand is very striking. Grows in clusters and spreads freely by throwing out roots wherever the joints touch the soil.

Grains ⅛ inch long, tapering; covered on inner side by dark purplish and more or less woolly husk, the outer side only partly covered.

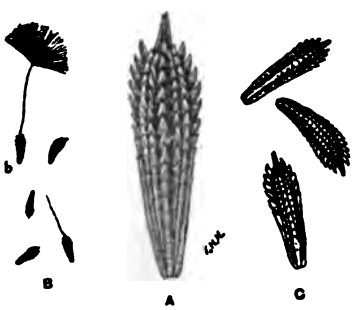

Fig. 20.

DANDELION. *Taraxacum officinale* Weber. A low perennial with long deeply cut leaves clustered around the base and yellow heads of flowers on stalks ½ to 1 foot high. Common in lawns.

Seeds dull brown, flask-shaped, ⅛ inch long, conspicuously barbed along the upper portion of the vertical ridges.

DEVIL'S PAINT-BRUSH. ORANGE HAWKWEED. *Hieracium aurantiacum* L. A low perennial, 1 to 2 feet high, common in lawns and permanent pastures. Leaves clustered around the base, flowers orange-red, the heads in clusters, stalks hairy.

Seeds purplish black, oblong, $^1/_{15}$ inch long, cut off square at the top, tapering at the base, 10-ribbed lengthwise, a fringe of white hairs at the tip.

Fig. 21.

Fig. 22.

DOCK, BITTER. DOCK, BROAD-LEAVED. *Rumex obtusifolius* L. A very robust perennial with erect, grooved and sparingly branched stem and large oblong, basal leaves.

Fruit triangular, light brown, sides nearly plane. The brown arrow-head-shaped calyx wings toothed.

DOCK, BROAD-LEAVED. See DOCK, BITTER (22).

Fig. 23.

DOCK, CURLED. DOCK, YELLOW. *Rumex crispus* L. A deep-rooted perennial, 2 to 4 feet high; smooth, erect, with large wavy-margined leaves and wand-like inflorescence.

Fruit triangular, reddish brown, shiny. The brown, heart-shaped calyx wings covering the fruit are entire.

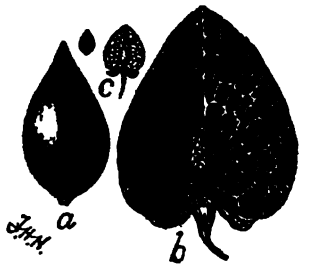

Fig. 24.

DOCK, PATIENCE. *Rumex patientia* L. The tallest and stoutest of our native docks, 2 to 6 feet high, with dense inflorescence and leafy stem. Margins of leaves not wavy.

Fruit triangular, light brown, shiny, angles very prominent, sides nearly plane. The brown heart-shaped calyx wings are entire.

DOCK, YELLOW. See DOCK, CURLED (23).

Fig. 25.

DODDER. LOVE VINE. *Cuscuta epithymum*, Murr. A small, yellow, parasitic twiner, bearing numerous clusters of whitish flowers. It has neither leaves nor roots but lives entirely on food robbed from the plant on which it grows.

Seeds $^{1}/_{10}$ inch in diameter, dull, grayish to yellowish brown, egg-shaped to spherical, minutely pitted. In some respects our worst weed.

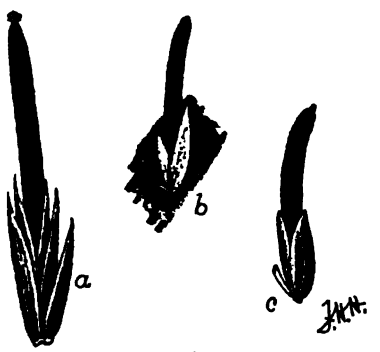

Fig. 26.

ERGOT. *Claviceps purpurea.* This is a poisonous fungus which attacks the ovary of many flowers and forms its fruiting body in place of the seed. It is common in redtop and is found occasionally in timothy, rye, etc. It is usually larger than the seed and is easily detected by its dark purple color.

FINGER GRASS. See CRAB-GRASS (19).

FIVE-FINGER. See CINQUEFOIL, COMMON (13).

Fig. 27.

FOXTAIL, GREEN. *Setaria viridis* (L.) Beauv. Similar in growth and habit to yellow foxtail (28) except that it has a more bristly inflorescence. The progenitor of the foxtail millets of cultivation.

Grains smaller than those of the yellow foxtail (28), their firm covering similarly marked by cross ridges, faintly striated lengthwise.

FOXTAIL, YELLOW. *Setaria glauca* (L.) Beauv. An annual weed 1 to 3 feet high with condensed, cylindrical and bristly inflorescence. Common in all kinds of soil.

Grains covered by hard, firm husk, light to dark brown, prominently ridged crosswise, the tip distinctly 3-toothed.

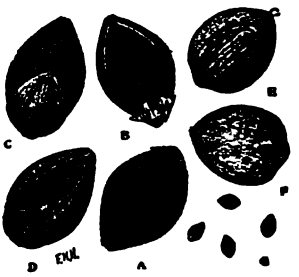

Fig. 28.

HAWKWEED. See DEVIL'S PAINT BRUSH (21).

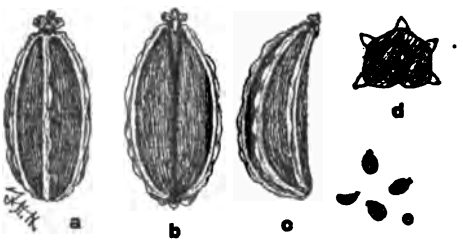

Fig 29.

HEMLOCK, POISON. *Conium maculatum* L. A tall plant closely resembling the water hemlock (30); its leaves more divided, its flower cluster denser. Grows in wet places. All parts of this plant are exceedingly poisonous.

Seeds grayish brown, formed in pairs, boat-shaped, five white ridges along the curved side, flat side dark gray.

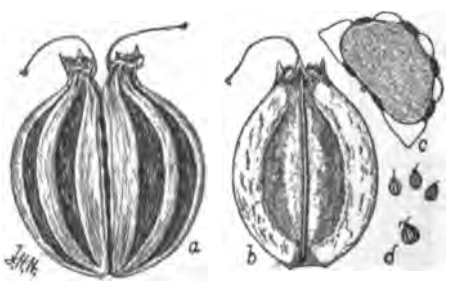

Fig. 30.

HEMLOCK, WATER. SPOTTED COWBANE. *Cicuta maculata* L. A tall carrot-like perennial growing in wet meadows. Stems 2 to 6 feet high, stout, hol-

low, many-branched, flowers white and in clusters like the carrot. Roots poisonous.

Seeds formed in pairs, boat-shaped, $^1/_{12}$ inch long, five yellow ridges along the curved side, flat side light with a brown center.

KALE. See CHARLOCK (10).

Fig. 31.

LADY'S THUMB. *Polygonum persicaria* L. An erect annual ½ to 2 feet high with lance-shaped leaves and condensed, pink inflorescence.

Fruit jet-black, triangular to lens-shaped, smooth and shiny.

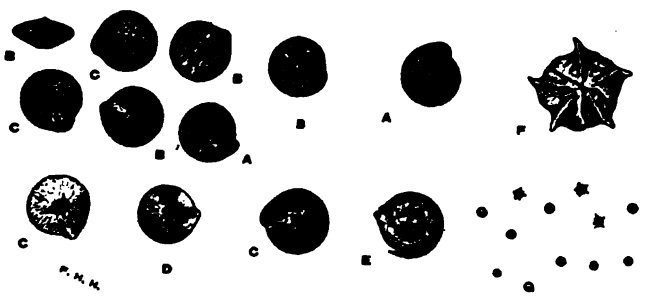

Fig. 32.

LAMB'S QUARTERS. PIGWEED. *Chenopodium album* L. A rapid-growing, light green and often purple colored annual, 2 to 4 feet high.

Seeds almost lens-shaped, more or less dull black; gray if not cleaned. A curved groove extends from near the center of one plane to the margin. This is one of the commonest impurities in commercial seed.

LUCERNE. See ALFALFA (1).

LOVE VINE. See DODDER (25).

MILFOIL. See YARROW (52).

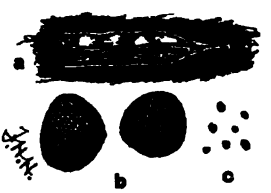

Fig. 33.

MUSTARD, BLACK. *Brassica nigra* (L.) Koch. An erect branching annual or biennial 2 to 7 feet high, flowers bright yellow, seeds in smooth 4-angled pods ½ to 1 inch long.

Seeds spherical, light reddish brown, delicately ridged.

MUSTARD, TUMBLING. *Sisymbrium altissimum* L. A slender, smooth profusely-branched annual with cream-colored flowers and a many-seeded slender pod 2 to 4 inches long.

Seeds olive brown, 1/16 inch long, oblong and angular, with a scar at the one end.

Fig. 34.

Fig. 35.

NIGHT-FLOWERING CATCHFLY. *Silene noctiflora* L. A common annual or winter annual growing in clover and alfalfa fields. Plants stout, 1 to 3 feet high, covered with sticky hairs, flowers large creamy-white.

Seeds light, grayish brown, flattened, kidney-shaped, roughened by rows of short teeth.

NONESUCH. See BLACK MEDICK (5).

ORANGE HAWKWEED. See DEVIL'S PAINT-BRUSH (21).

PAINT-BRUSH. See DEVIL'S PAINT-BRUSH (21).

Fig. 36.

PARSNIP, WILD. *Pastinaca sativa* L. A plant resembling the cultivated parsnip. Stems 2 to 4 feet high, smooth, hollow, grooved, yellow flowers in carrot-like clusters. Roots poisonous.

Seeds light brown, ¼ inch in diameter, formed in pairs, round and flat.

PIGWEED. See LAMB'S QUARTERS (32).

Fig. 37.

PIGWEED, ROUGH. *Amaranthus retroflexus* L. A very rapid growing annual which is seldom absent from cultivated fields. One to 6 feet high, with a dense, dock-like inflorescence, large red root.

Seeds lens-shaped, smooth, highly polished, reddish black to jet-black.

Fig. 38.

PLANTAIN, BROAD-LEAVED. *Plantago major* L. A low, tufted perennial common in lawns and meadows. Leaves in a cluster from the base, oval, flowers small, borne in a rat-tail-like inflorescence.

Seeds brown to black, varying greatly in size and shape, rounded on the outside, angular on the inside, minutely netted.

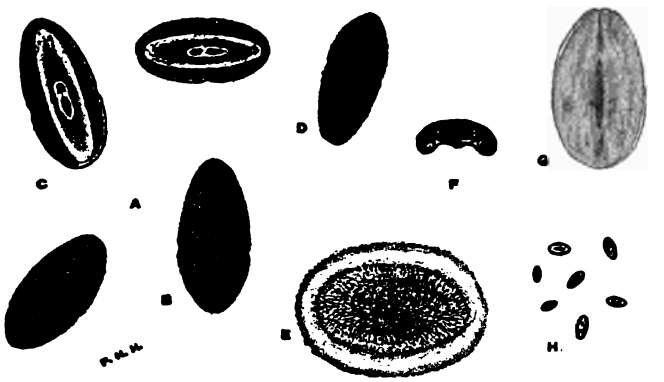

Fig. 39.

PLANTAIN, LARGE-BRACTED. *Plantago aristata* Michx. A low, densely tufted, grass-like annual, 8 to 15 inches high. Leaves narrow, grass-like, flowers small, borne in a rat-tail-like inflorescence, these bracted.

Seeds dull, boat-shaped, light gray inside, dark brown outside, the outer face divided into two equal halves by a groove running crosswise.

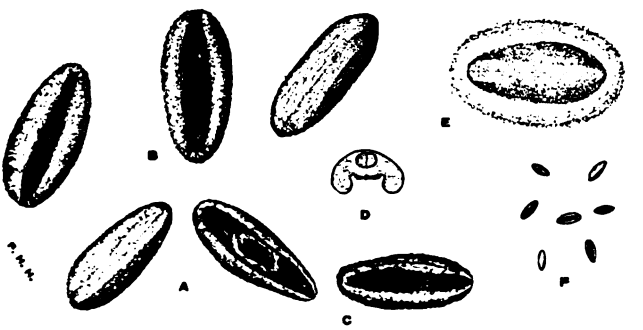

Fig. 40.

PLANTAIN, NARROW-LEAVED. RIB-GRASS. *Plantago lanceolata* L. A low tufted perennial, common in grasslands. Leaves in a cluster from the roots, narrow, flowers in an elongated cluster at the end of a slender, grooved stalk.

Seeds chestnut brown, polished, boat-shaped, rounded ends, a scar of attachment on the inner face.

Fig. 41.

PLANTAIN, RUGEL'S. *Plantago rugelii* Decne. Similar to the Broad-leaved Plantain (38) and often confused with it. Leaves broader, inflorescence narrower, leaves and stalks crimson at the base.

Seeds almost black, varying greatly in size and shape as in the broad-leaved variety (38), but larger and having a prominent scar, not netted.

Fig. 42.

PRIMROSE, COMMON EVENING. *Oenothera biennis* L. A common roadside plant, 2 to 6 feet high, usually unbranched, large pale yellow flowers borne in the axes of the upper leaves.

Seeds dull reddish brown, very irregular both in shape and size, ridged parallel with the sides.

Fig. 43.

PURSLANE. *Portulaca oleracea* L. A fleshy, smooth, many-branched, creeping annual with small, yellow flowers. Its succulent stem and leaves enable it to live for a long time after pulling.

Seeds jet-black, roughened but shiny, flattened, narrowly kidney-shaped, with a curved point at the place of attachment.

QUACK GRASS. See COUCH GRASS (18).

Fig. 44.

RAGWEED, COMMON. *Ambrosia artemisifolia* L. A coarsely branching annual, 2 to 4 feet high, common in cornfields and waste places. Leaves deeply cut, flowers small and of two kinds, borne in elongated clusters.

Seeds light brown, 1/8 inch long, urn-shaped, with a large beak at the upper end, 7 to 10 small teeth on the upper edge.

RIB-GRASS. See PLANTAIN, NARROW-LEAVED (40).

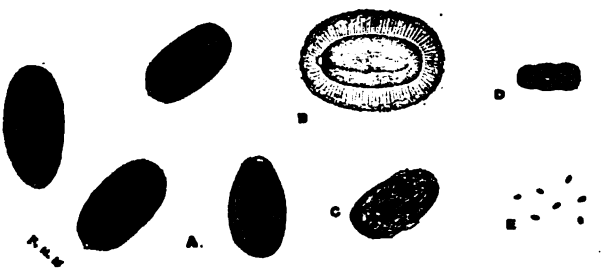

Fig. 45.

SHEPHERD'S PURSE. *Capsella bursa-pastoris* (L.) Medic. A deep-rooted annual, 1/2 to 2 feet high with small, white flowers clustered at the tip of each branch. Its flattened, triangular, purse-like pod is a distinguishing character.

Seeds reddish brown, 1/24 inch long, oblong, grooved on the sides.

Fig. 46.

SMARTWEED, COMMON. *Polygonum hydropiper* L. A smooth, erect, slender annual weed, 1/2 to 2 feet high, growing in wet, swampy places. Its pungent juice keeps live stock from eating it.

Fruit dull, reddish brown, triangular to lens-shaped, minutely ridged and pointed tip.

SOAPWORT. See BOUNCING BET (8).

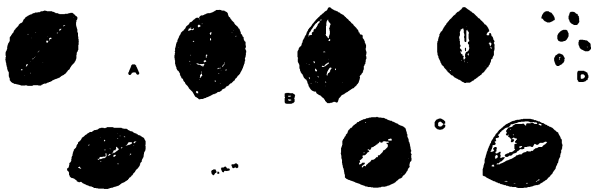

Fig. 47.

SORREL, SHEEP. *Rumex acetosella* L. A very persistent perennial weed spreading freely by its yellow, branched root-stocks. Stems erect and profusely branched, leaves narrow arrow-head-shaped and largely basal.

Fruit $^1/_{20}$ inch long, dull brown with acute apex and rounded base, triangular and minutely ridged.

SPOTTED COWBANE. See HEMLOCK, WATER (30).

Fig. 48.

THISTLE, BULL. *Cirsium lanceolatum* (L) Hill. A stout, much-branched plant, 3 to 5 feet high, common in pastures. Similar to the Canada thistle, but coarser and with larger flower heads.

Seeds gray to white, striped along the side, elongated, somewhat flattened and curved, ⅛ inch long, the upper end having a narrow rim with a conical point in the center.

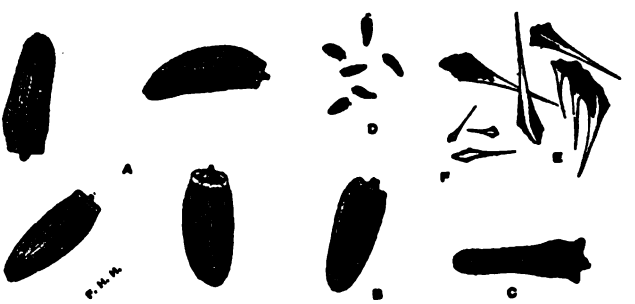

Fig. 49.

THISTLE, CANADA. *Cirsium arvense* (L.) Scop. An erect, much-branched perennial, 2 to 4 feet high, spreading profusely by deep-running rootstalks. Leaves deeply cut and very prickly, flowers in heads, pale purple. The commonest thistle in Vermont.

Seeds light brown, smooth, elongated, somewhat flattened and curved, ⅛ inch long, the upper end having a narrow rim with a conical point in the center.

TWITCH GRASS. See COUCH GRASS (18).

WILD BUCKWHEAT. See BINDWEED, BLACK (3).

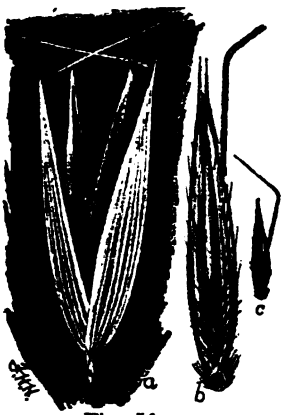

Fig. 50.

WILD OAT. *Avena fauta* L. An annual weed found occasionally in grain fields. In general appearance it closely resembles some varieties of cultivated oats but with long awns which at maturity are very much twisted and bent so as to form right angles. A common impurity in western grown seed.

Grains in a hard, rough, thinly hairy, usually brown husk varying greatly in size as does the oat which it resembles in shape. Its firmly twisted dorsal awn and its saucer-shaped lower portion distinguishes it from the oat.

WITCH GRASS. See COUCH GRASS (18).

WITCH GRASS, OLD. *Panicum capillare* L. A very hairy, spreading, annual grass, 1 to 2 feet high. Its spherical inflorescence when mature is easily broken off and rolled by the wind as a "tumbleweed."

Grains covered by shiny, gray husk $^{1}/_{16}$ inch long, the outer marked by five distinct vertical lines.

Fig. 51.

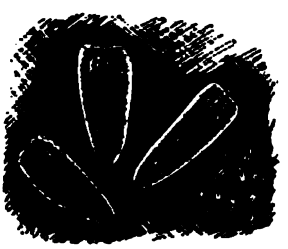
Fig. 52.

YARROW. MILFOIL. *Achillea millefolium* L. A very hardy perennial, 1 to 2 feet high, common in pastures and along roadsides. Leaves large and finely cut, small, white flowers borne in flat-topped clusters.

Seeds gray, $^{1}/_{16}$ inch long, flattened, wedge-shaped, indistinctly ridged lengthwise.

YELLOW DAISY. See BLACK-EYED SUSAN (6).

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OCTOBER, 1916 BULLETIN 201

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

VALUE OF DIFFERENT GRADES OF MILK IN INFANT FEEDING

By R. M. WASHBURN and C. H. JONES

(Popular Edition of Bulletin 195)

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BULLETIN 201: VALUE OF DIFFERENT GRADES OF MILK IN INFANT FEEDING

By R. M. WASHBURN, (FORMERLY) ANIMAL AND DAIRY HUSBANDMAN AND C. H. JONES, CHEMIST

INTRODUCTION

It has been said by way of criticism—and not without reason—that federal and state funds have been spent in the interests of farm productivity and prosperity rather than in the promotion of the health and wellbeing of farm occupants; that in stressing the conservation of our natural resources, we have in some measure lost sight of the need of conserving human resources; and that economics has been deemed more important than home economics and animal life better worth saving than human life. However that may be, it has seemed worth while to make some contribution at this Station to the study of infant feeding; and bulletin 195 entitled "Studies of the Values of Different Grades of Milk in Infant Feeding," is the first fruits of this effort.

There are about 2,250,000 babies in the United States less than a year old. Fully two-thirds of them are fed artificially before they are able to digest solid food, and practically all of them consume cows' milk as their chief or sole diet before they are a year old. Nearly as many children between the ages of one and two years use cows' milk in conjunction with other foods; indeed the second year of a child's life is a critical period, especially if improperly nourished during the first year. The mortality of bottle-fed infants in the United States is nine times that of those who are breast-fed. It is said that "more than 90 percent of all cases of rickets is among bottle babies." The pitiable ignorance and helplessness concerning the correct feeding and care of infants displayed by many mothers, particularly in the congested sections of our large cities, is appalling. Much has been done of late to teach and aid mothers, more particularly along lines of sanitation; but the last word has not yet been said as to the dietetical fitness of various grades of milk to infant feeding.

About one-sixth of the milk produced by our 22,000,000 dairy cows is used as food for infants and young children. Surely fitness to its special purpose of this one-sixth of the total supply is of more vital consequence than that of the remaining five-sixths; yet the study of the proper usage of this one-sixth has received but a modicum of the attention that has been given the usage of the five-sixths.

Prior to the establishment of the Children's Bureau of the Federal Department of Commerce and Labor, little has been available concerning the feeding of infants and the rearing of children, nor has it been had in any other way for the asking, except when circulated to advertise proprietary infant foods. However valuable publications made by commercial houses may be, the prime motive back of such publications is frankly commercial, and it is not possible always to be sure of their disinterestedness and reliability. A disinterested, extensive, thoroughly careful inquiry by an experiment station ought to serve a good end.

The experimental trials discussed in full in the technical bulletin, were carried on at this Station during several years and were designed to throw light on the following questions:

1. What fat grade of milk is best adapted to the growth and well being of young animals?
2. Is a milk the fat globules of which are relatively small, on that account preferable in the feeding of young animals to a milk the fat globules of which are relatively large?
3. Does the process of homogenization improve milk as a food for young animals?
4. Are condensed (sweetened) or evaporated (unsweetened) milk well adapted to infant feeding?
5. To what extent is the strength of the bones affected by food changes?
6. Does the dilution of a ration affect its food and energy values?
7. In the light of the results attained in the present studies and of previous trials, the observation of the writers touching infant feeding, and the testimony of pediatrists, what broad principles may be laid down touching infant feeding?

Comparative trials of grade Holstein-Friesian and Jersey milks were made in the attempt to secure answers to the first two questions. The efficacies of the several rations were not determined by gross gain weights, but by dry matter gains, by a study of the composition of those gains, and by the clinical evidences of thrift or the reverse.

DIFFERENCES BETWEEN HOLSTEIN AND JERSEY MILKS

It is often claimed that Holstein milk is superior as a food for the young. In support of this view it is said that difficulty is seldom experienced in rearing Holstein calves on their dams, whereas calves fed on milk rich in fat sometimes suffer from acute indigestion or diarrhoea, at the same time that those receiving milk of a lower fat

content suffered no intestinal disorders and grew vigorously. Some physicians maintain that in their experience Holstein milk proved superior to Jersey milk in infant and invalid feeding, although seldom stating wherein it excels. Some attribute its superiority to its lower fat content and to the smaller size of its fat globules. Many parents are willing to pay a higher price for this type than for other types of milk for infant feeding. On the other hand much testimony is at hand favoring the use of high fat milk. In fact so many diverse statements are made in support of both claims, that it seemed well worth while to attempt to secure data which might be pertinent.

Holstein and Jersey milks differ in at least four respects:

1. *In fat percentage.* Holstein milk usually contains from 3 to 3.8 percent fat, while Jersey milk usually carries from 5 to 7 percent fat. Only one-fourth of the solid matter of Holstein milk is fat whereas two-fifths of the solid matter in Jersey milk is fat.

2. *In the ratio of fat to solids-not-fat.* Holstein milk contains less fat in proportion to the solids-not-fat than does Jersey milk, the ratios being 1 : 2.4 and 1 : 1.8 respectively.

3. *In the size of the fat globules.* The average Holstein fat globule is about 1-12,000 inch, while the average Jersey fat globule is about 1-9,000 inch in diameter. Now the average diameter of the fat globules in human milk seems to be intermediate between those of Holstein and Jersey milks. Photomicrographs, displayed opposite page 16, afford a fairly clear idea of the relative sizes of grade Holstein, grade Jersey and human milk fat globules.

4. *In the proportion of casein to albumen.* The comparative proportions of casein and albumen are approximately: Holstein, 77 and 23; Jersey, 82 and 18.

No attempt was made to determine the validity of the claim which is sometimes made that the greater strength, docility and contentedness of the Holstein imparts to her milk a "vitality" not possessed by milk of other breeds. The relation of fat contents and of fat globule sizes were the main matters taken into account.

"Baby pigs" were used in these trials. Pigs are born in litters, thus enabling six or more of the same age and inheritance to be used in the same test. The question may be asked whether results attained with pigs are applicable to the feeding of the human infant. It may be said in answer that students of animal nutrition long have recognized the similarity existing in the fundamental digestive processes of all animals. Little or no systematic observation, much less experimental

study, has been made in relation to the human. The pig is an animal which is recognized to be in reality physiologically very similar to the human, and it should furnish data of value in the study of the feeding of the human for "it is self-evident that the infant belongs to the animal kingdom and is accordingly subject to the general laws of animal nutrition." Indeed, striking evidence had been adduced before the Vermont trials were started that the suckling pig reared on skimmilk conforms to the same laws of nutrition as does the breast-fed infant.

One hundred and sixty-two pigs, representing 23 litters, were used in these trials. The body composition of each pig—except four which died—was determined. Twenty-four were killed at the outset of the several trials in order that the chemical data thus secured might be used as a check, indicative of the original body composition of the pigs in the several litters which were experimentally fed.

The pigs were fed in groups of 6 to 18 for from 30 to 67 days, a total of 6,865 "pigs-days" equivalent to 18.8 years of pig-life.

GENERAL OUTLINE OF WORK ON WHICH RESULTS ARE BASED

Number of pigs used in investigation	162
Representing litters	23
Total pig-days	6,865
Number of carcasses analyzed	158
Number of carcasses not analyzed (died)	4
Pigs, other than check, used in compiling average	105
Check pigs analyzed	24
Carcasses analyzed; results omitted from average	29

CARE OF THE BABY PIGS

The experimental animals were housed in a small building especially designed for the purpose of these trials. The floor was cement, shavings were usually employed as litter, and individual pens were used. The pig in each lot whose weight was nearest the average was killed at once, its body prepared for analysis and the results used as a check for that litter. Since no data were available indicating how much food is required for the maintenance and growth of young pigs, they were given all they would consume readily. Repeated failure to display a keen appetite at meal time was followed by a reduction in the amount of food furnished. At first they were fed thrice daily, but later only twice.

The duration of these trials was intended to fall within the age limit when the development of the pigs would be comparable with that of a child during its normal milk-consuming period; yet their length varied somewhat, depending more particularly upon the condition of the animals and the season. The infant pig is more fully developed at

birth than is the human babe and it matures more rapidly. The experimental pigs were from four to five weeks old at the beginning of the trials, an age comparable to that of a human infant four to five months old. For a few weeks thereafter each week of a pig's life approximately corresponds to a month in a child's life; yet a year-old pig is more mature than is a human being 12 years old.

FOOD

The milk used was furnished by grade Holstein-Friesians and registered and high-grade Jerseys. All the milks were centrifugally skimmed and the Holstein cream mixed with Holstein skimmilk and the Jersey cream with Jersey skimmilk in definite proportions in order to secure the several desired grades. By thus standardizing the milks their fat contents were made essentially identical and diverseness as to size of the fat globules was made the chief variant. The pigs were fed three grades of milk, namely, skimmilk, milk standardized to test approximately 2.5 percent of fat, and milk standardized to test approximately 5 percent of fat. Homogenized milk was processed in the dairy laboratory. The condensed and evaporated milks which were used were standard commercial brands.

In due time each pig was taken to a well equipped slaughter laboratory and there so handled that blood, viscera, skeleton and all soft tissues (flesh, fat, etc.) were separately secured. Throughout the operations a careful check was kept on all weights and the several analyses of blood, viscera, skeleton and soft tissues were finally calculated to the basis of the original animal.

COMPOSITION OF BABY PIGS WHEN FEEDING BEGAN

The following statement sets forth the body composition of the 24 pigs slaughtered at the beginning of the trials and used as checks upon the effect of the various diets fed their mates. Since these baby pigs, four to five weeks old, had been nourished in every case by their own mothers and were thoroughly normal and active, it may be assumed that the ratio of chemical substances of their bodies must have been approximately normal and best for their health and well being. Their weights varied from about 12 to nearly 30 pounds, the average being 18.3 pounds. The average baby pig seems to consist—from the chemical point of view—of one-third dry matter and two-thirds water, the ash comprising one-tenth and the protein and fat each a little more than three-sevenths of the dry matter. The average composition of a

child's tissue at birth is shown for purposes of comparison. It is interesting to note the similarity in the ratio of protein to fat.

CHEMICAL COMPOSITION OF YOUNG PIGS AND OF THE HUMAN INFANT

	Water percent	Dry matter percent	Ash percent	Protein percent	Fat percent	Ratio protein to fat 1:
Young pigs	66.62	33.38	3.17	15.30	14.51	0.95
Human infant	71.8	28.2	2.7	11.7	12.3	1.05

SKIM-, MEDIUM AND RICH MILKS

Information was sought in these trials concerning several matters: the amount of fat which should be fed; the ratio the protein content should bear to the fat content; the effect produced upon the health, growth and body composition of the several animals by feeding milks of varying fat contents; the kind of body tissue formed when rations of different but definite chemical composition are fed; and the bearing of the results attained upon the feeding of the human infant. No attempt was made to secure economical pork production.

The skimmilk fed pigs gained about 10 ounces daily in live weight, those fed 2.5 percent milk nearly 12 ounces and those fed 5 percent milk nearly 15 ounces; their dry matter gains were respectively, in round figures, 3½, 5 and 7 ounces. The nutritive ratios, i. e., the ratios of nitrogenous to carbonaceous nutrients, were respectively 1 : 1.28, 1 : 2.90 and 1 : 4.27 and these were reflected in the ratios of protein to fat in the gains made by the animals to which they were fed, 1 : 0.86, 1 : 1.61 and 1 : 2.52.

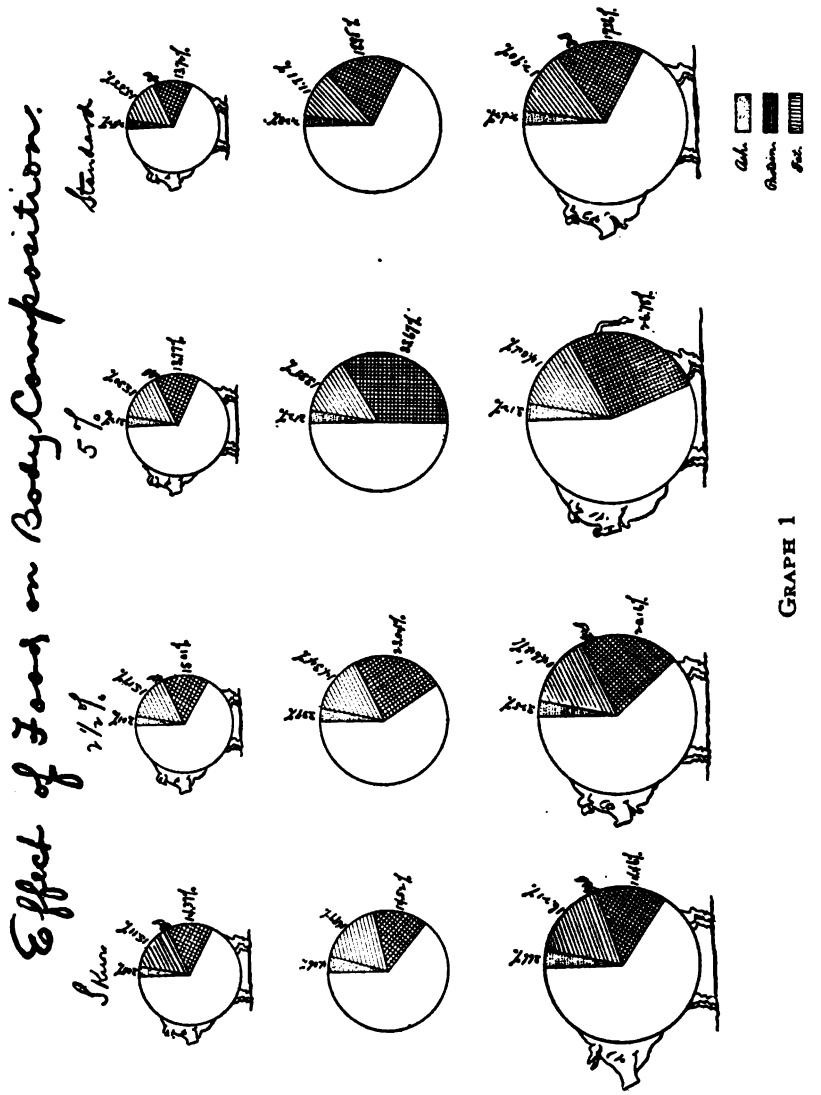
The skimmilk pigs laid on flesh rather than fat. The relativity of the protein and fat contents tells this story most clearly. The average standard fed pig, a physically perfect animal, showed a protein to fat ratio of 1 : 1.62. It seems safe to say that this 1 : 1.62 protein to fat ratio may be assumed to be approximately the desirable one in early pig life. The ratio which the skimmilk group displayed is a very different one—1 : 0.86, resembling that of the young pigs when feeding began. The vigor of the skimmilk-fed animals was remarkable.

The large deposition of fat which occurred when 5 percent milk was fed deserves special attention. The gain made contained 13.38 percent protein and 33.67 percent fat, and a protein to fat ratio of 1 : 2.52, which is much wider than that obtained with the standard group. The body gain of the fat-fed pigs was half and half while

that of the standard-fed group was one-third and two-thirds dry matter and water. The health of the fat-fed pigs was far from good. Serious digestive disturbances frequently occurred, they often appeared dull and logy and their vigor obviously was impaired. Indeed, whenever the quantity of fat in the animal body exceeded the quantity of protein by more than about 50 percent, the animal became sluggish, peevish, of low vitality and, though handsome, was physically abnormal.

The constancy with which change in the nutritive ratio of the food was reflected in modification of the proportion of muscular tissue to adipose tissue, was striking. This fact, when taken into account in connection with the clinical observations, furnishes some of the most significant evidence which has come thus far to the attention of the writers and affords food for thought concerning prevailing methods of infant feeding. In all cases where the quantity of body fat was less than the quantity of muscular tissue the pigs obviously were lean, angular and under-sized. The over-fat pigs were in a dangerous condition and the under-fat in an indifferent condition. The ideal was attained more nearly when milk with 2.5 percent fat and a nutritive ratio of about 1 : 3 was fed, which, it may be remarked parenthetically, is in entire accord with the experience of livestock men who grow young animals for profit. Furthermore, whenever digestive disturbances arose when a high-fat ration was fed they were rectified by putting the animal on a skimmilk diet for a day or two. A 5 percent fat ration may be adapted to the purpose of a full-grown, mature animal that one wishes to fatten, but appears unfitted to grow an animal in the formative period of its life.

Graph 1 shows the average composition of the check pigs killed at the outset of the trials (upper horizontal column), of the gains (middle horizontal column), and of the pigs when killed (lower horizontal column). The pictures—if such they may be called—are drawn to scale. The left hand perpendicular column shows the average composition of the skimmilk group at start and finish, and the difference between the two is represented by the middle circle, which indicates the composition of the gain; the second perpendicular column affords similar information as to the animals fed 2.5 percent milk; the third perpendicular column of the 5 percent fat-fed animals. It should be remembered that all the pigs were on a par at the outset, that at the start the bodies of the four check pigs contained essentially uniform amounts of water, ash, protein and fat.



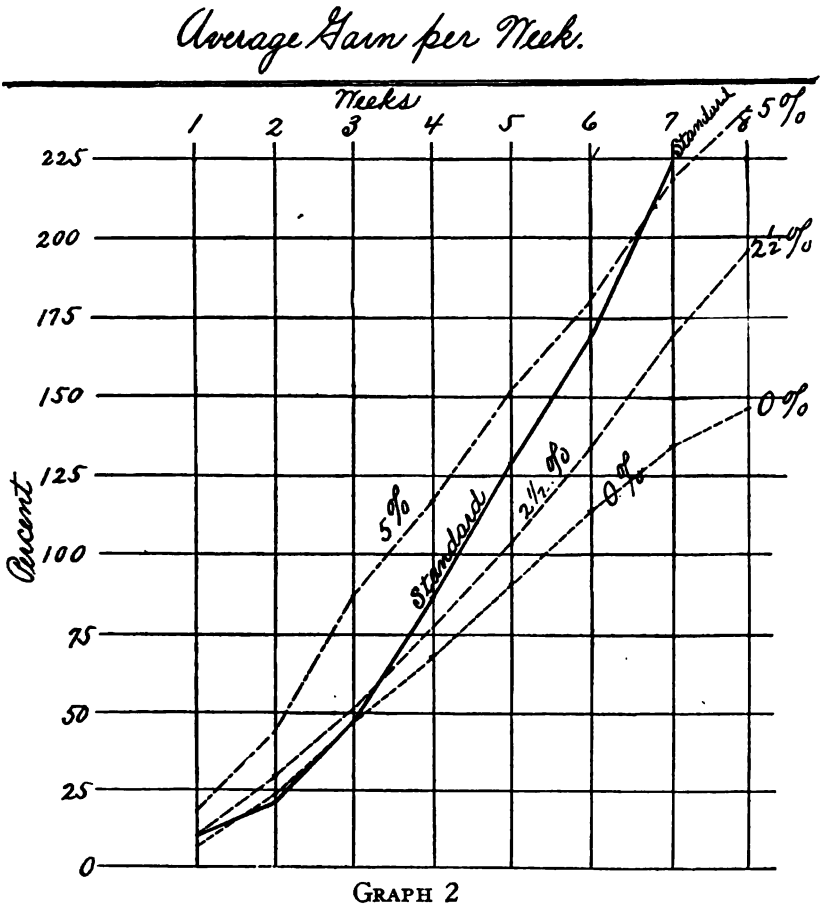
GRAPH 1

The gains, or center circles, feature the points with which we are chiefly concerned. The gradual increase in body fat as more food fat is ingested is clearly indicated as one reads from left to right on the center circles, the percentages being 14.52, 23.04 and 33.67.

While a rapid increase in weight usually means economy in gain, it does not follow necessarily that such an increment is desirable from the standpoint of the well being of the animal. Considered alone, mere gain in weight is a poor criterion by which to judge the value of a food when fed to the young of any species. A fat baby is not necessarily

a healthy baby. The hospital records and seriously impaired vitalities of the rich milk pigs should be remembered if one is tempted to make use of their records in formulating dietaries intended to induce normal and desirable body gains in human or brute creation.

The following graph shows the progress of body gain. The skim-milk fed pigs doubled their weight in 35 days, those fed medium grade milk in 32 days, those fed rich milk in 26 days.



GRAPH 2

The following table making direct comparison of the ratios of the food nutrients and the body gains is deemed to be significant.

RATIOS

	In food consumed					In gain		
	Protein		Milk sugar		Fat	Protein		Fat
Skimmilk	1	:	1.3	:	0	1	:	1.9
2.5 percent milk	1	:	1.3	:	1.6	1	:	3.6
5 percent milk	1	:	1.3	:	2.9	1	:	5.7

The writers hold that the bearing of the nutritive ratio of a food for the young on the formation of body tissue is important and that in the feeding of the human infant proper relations between the milk sugar and fat contents of its ration as well as the proper proportioning of these to the protein contents are vital matters.

CONCLUSIONS

1. The character of the tissue produced is determined by and closely parallels the chemical composition of the food consumed.

2. A ration supplying a large amount of protein in proportion to the total energy available (e. g. skimmilk) produced sturdy, agile, but rough and undersized pigs.

3. Milk carrying a medium fat content (2.5 percent) and, hence, less protein in proportion to the total units of energy available than does skimmilk, produced healthy, active and fair sized pigs.

4. Milk containing a large quantity of fat (5 percent) in proportion to protein, produced a rapid increase in weight and physiologically economical gains; but the pigs were in a dangerously over-fat condition and betrayed peevishness and low vitality.

5. The body of the young pig and, if the results of these trials are applicable to human infant feeding, that of the human young, should not contain much more than approximately 1.6 parts of fat for every one part of protein. If a ration carrying a nutritive ratio of about 1 : 3 is used, a 1 : 1.6 result, or an approximation to such a result, may be expected.

SMALL AND LARGE FAT GLOBULES

What is the effect on the body gain of the ingestion of different sizes of fat globules? The fat globules in Holstein milk average smaller than do those in Jersey milk, the relative average diameters being 1-12,000 inch in the Holstein and 1-9,000 inch in the Jersey, an average difference of 1-36,000 inch.

The 2.5 percent milk-fed pigs gained about 13½ ounces daily in live weight and those fed 5 percent milk about 15 ounces. Their dry matter gains were respectively, in round figures, 6½ and 7½ ounces. The nutritive ratios of the food approximated 1 : 2.8 and 1 : 4.2, and these were reflected in the ratios of protein to fat in the gains made by the animals to which they were fed, which were 1 : 2 and 1 : 2.58.

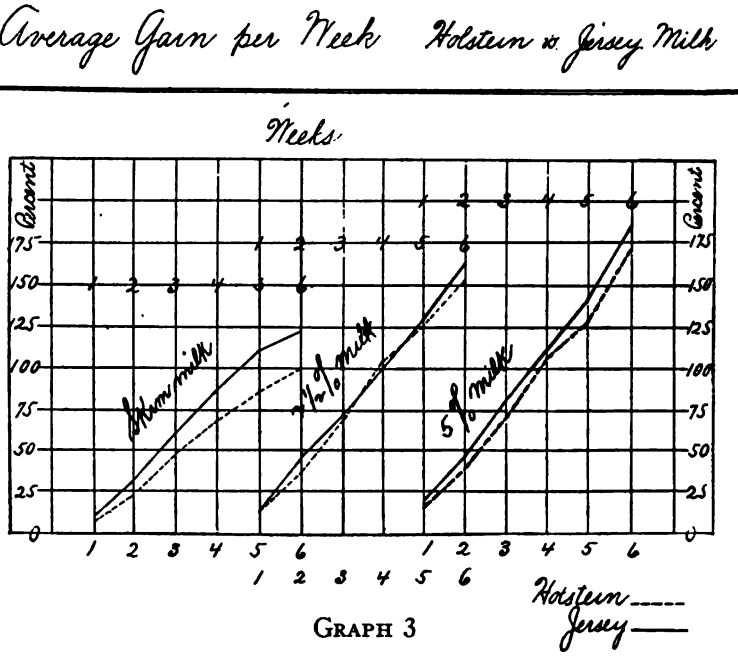
The comparison as between the milks of different origins may be stated as follows:

		Daily gain		Nutritive ratio of foods	Ratios protein to fat in gain
		Live weight	Dry matter	1:	1:
Holstein	2.5%	14 oz.	6 oz.	2.9	1.8
Jersey	2.5%	13½ oz.	6½ oz.	2.8	2.2
Holstein	5%	15 oz.	8 oz.	4.3	2.6
Jersey	5%	14½ oz.	7 oz.	4.2	2.5

While the body gain of the pigs fed 2.5 percent Holstein milk contained more protein and less fat than that of the pigs which ate Jersey milk of similar grade, both lots were satisfactory as viewed from the standpoint of stamina and there was little difference between them.

When 5 percent milks of Holstein and Jersey origin were fed the results with both groups were quite uniform as regards the protein to fat ratios; but in general the outcome was the reverse of what was secured when skim- or low-fat milks were fed. The results, which seem slightly to favor the Holstein milk, were less marked than those secured when 2.5 percent milk was fed.

The Jersey skimmilk-fed animals made increased gains over the Holstein group throughout the feeding period. When 2.5 percent milk was used, the Jersey-fed group led for three weeks, when it was passed by the Holstein-fed group, which in its turn was passed at the end of six weeks feeding. The Jersey-fed group receiving rich milk kept consistently in the front for seven weeks, though by a narrow margin. These gains are well shown in the following graph, wherein the slight predominance of the Jersey milk when skim- and rich milks were fed and the essentially identical outcome when medium grade milk was used are made manifest.



GRAPH 3

The following table making direct comparison of the ratios of the food nutrients and the body gains is deemed to be significant.

RATIOS

	In food consumed					In gain		
	Protein		Milk sugar		Fat	Protein		Fat
Holstein 2.5 percent milk.	1	:	1.4	:	1.5	1	:	4.
Jersey 2.5 percent milk...	1	:	1.2	:	1.5	1	:	5.
Holstein 5 percent milk..	1	:	1.4	:	2.8	1	:	5.9
Jersey 5 percent milk....	1	:	1.3	:	2.9	1	:	5.7

CONCLUSIONS

1. When 2.5 percent milks of grade Jersey and of grade Holstein origins were fed, the animals did uniformly well. They exhibited no marked preference for either milk. The analytical results seemed slightly to favor the Jersey-milk-fed group.

2. When 5 percent milks were fed, the animals did uniformly ill, so far as could be noted by observation. Clinical studies of the two groups indicated no essential differences.

3. If on account of the fact that its fat globules are smaller Holstein milk is superior as a food for the young as compared with the milk containing relatively large fat globules, such a superiority certainly was not clearly manifested in these trials. If it exists, the writers are inclined to believe that it is practically a negligible factor.

4. The superiority for infant feeding attributed to Holstein milk, if really existent, seems far more likely to lie in its relatively low fat content than in the relatively small size of its fat globules.

HOMOGENIZED MILKS

Milk is homogenized when it is rendered homogeneous, when its various particles are reduced as nearly as may be to a uniform size. This condition is brought about by means of a machine which consists essentially of a system of three or more pumps which force the milk through a small aperture against a hard surface, under a pressure of from 1,000 to 5,000 pounds to the square inch. This treatment breaks the fat globule into many smaller globules or particles, and makes of the milk a more nearly complete emulsion, thus greatly retarding the separation of cream. It is claimed that homogenized milk is more easily digested on account of the greatly reduced size of its particles.

The results of the trials thus far discussed seemed to indicate that Holstein milk is no better adapted to infant feeding than is Jersey milk, when the fat contents of the two milks are identical; that in this respect the size of the fat globule is either a negligible or a non-existent factor. Yet there are those who earnestly believe in the dogma of the superiority of Holstein milk for this purpose, basing their belief upon the theory that a portion of the fat is absorbed in the intestinal tract in the same condition in which it is ingested and that the more minute the subdivision of a nutrient the more easily it is absorbed and the greater its nutritive value. If this point of view is valid, homogenization of milk should be worth while economically. Manufacturers of homogenizing machinery very naturally have accepted this doctrine.

The photomicrographs of Jersey, Holstein and homogenized Jersey milk fat indicate that the Holstein globule is a little smaller than the Jersey globule and, furthermore, that the homogenization process, particularly at 185° F., decidedly reduced the size of the fat globules. The writers feel that any organism sensitive enough to recognize the slight difference in size between Holstein and Jersey fat globules should distinguish the normal from the homogenized milk fat, between which still greater differences exist.

If the homogenization of the fat globules in milk is advantageous in nutrition, the fact should be manifested in the greater palatability of the food, increased rate of gain, in the general well being of the animal and in the effect upon the number of units of food material

required for the deposition of a unit of body tissue or, expressed in other words, in the percentage utilization of the energy consumed.

All of the pigs which received normal milk fat consumed their portions greedily and made prompt gains, while those receiving homogenized milk fat apparently disliked it at first. It was observed throughout the entire trial that the pigs from all the litters which were fed homogenized fat were not inclined to gorge themselves, that it was not relished as well as was the fat derived from the normal milk even though they had never been accustomed to cows' milk.

Microscopic examination of the fat homogenized at 85° F. indicated that the treatment was not particularly effective, whereas homogenization of the fat globule conducted at 185° F. was far more thorough, as shown in photomicrographs in Plate I.

Some pigs were fed normal milks carrying about 2.5 percent, from 4.5 to 5. 5 percent, 7 percent and from 6.7 to 8.2 percent fat; and others were fed homogenized milks of similar fat contents. The essential results were as follows:

		Daily average live weight gain	Daily average dry matter gain	Nutritive ratio food 1:	Ratio protein to fat in gain 1:
Normal,	2.5%.....	15 oz.	6+ oz.	3	1.46
Homogenized,	2.5%.....	16— oz.	7+ oz.	2.7	1.74
Normal,	4.5-5.5%.....	18— oz.	7½ oz.	4.7	1.60
Homogenized,	4.5-5.5%.....	20+ oz.	8½ oz.	4	1.44
Normal,	4.7-7%	8— oz.	2½ oz.	5.7	1.29
Homogenized,	4.7-7%	7+ oz.	8 oz.	4.3	0.85
Normal,	6.7-8.2%.....	18 oz.	9½ oz.	6.7	3.47
Homogenized,	6.7-8.2%.....	21 oz.	11 oz.	5.7	3.19

An increased retention of fat in the body gain when homogenized fat was fed was evident in the 2.5 percent fat-fed pig. When, however, homogenized fat in milk of about 5 percent grade was fed, the results were reversed. A larger proportion of fat, associated with protein, was stored when the normal milk was fed. When homogenized and normal milks of high fat contents—6.67 to 8.21 percents—were fed, relatively less protein and more fat were stored. An excessive fat content in the ration is reflected in the gains.

None of the 10 animals used in the third trial responded to their rations as well as might be desired. The ratio of protein to fat in gain were far below normal in every case, in view of the quality of the ration eaten. The animals thus fed showed poor tolerance for fat. The fat retentions, as evidenced by the percentages of fat in the gain

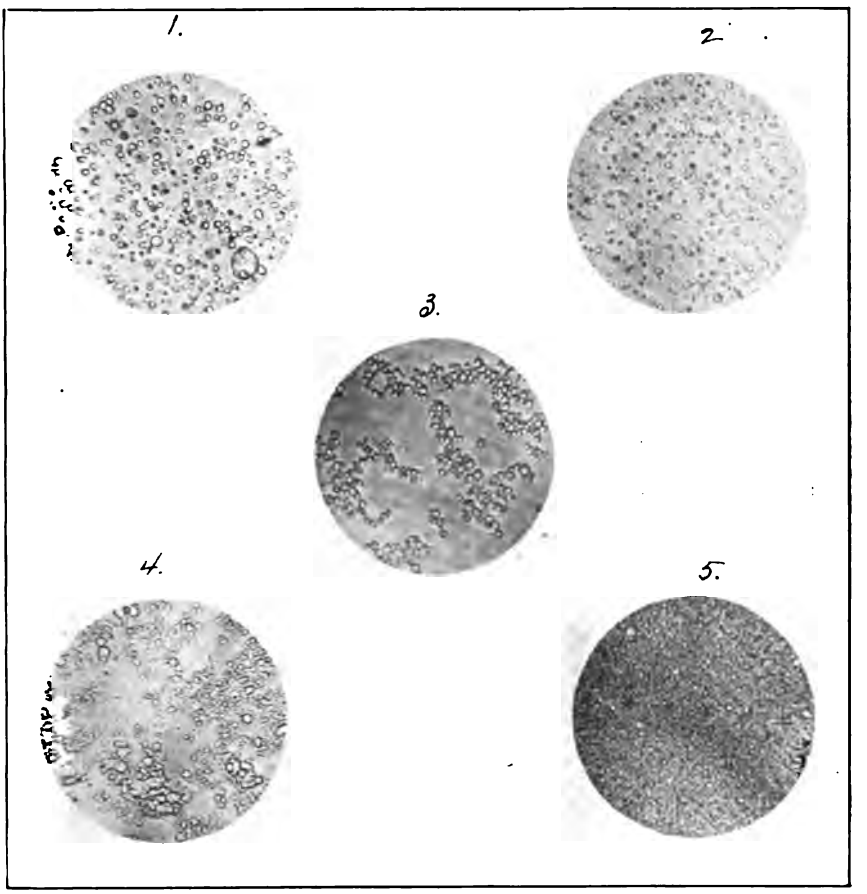


PLATE I. Photomicrographs of fat globules in milk.

1. Grade Jersey.
2. Grade Holstein.
3. Human.
4. Homogenized at 85° F.
5. Homogenized at 185° F.

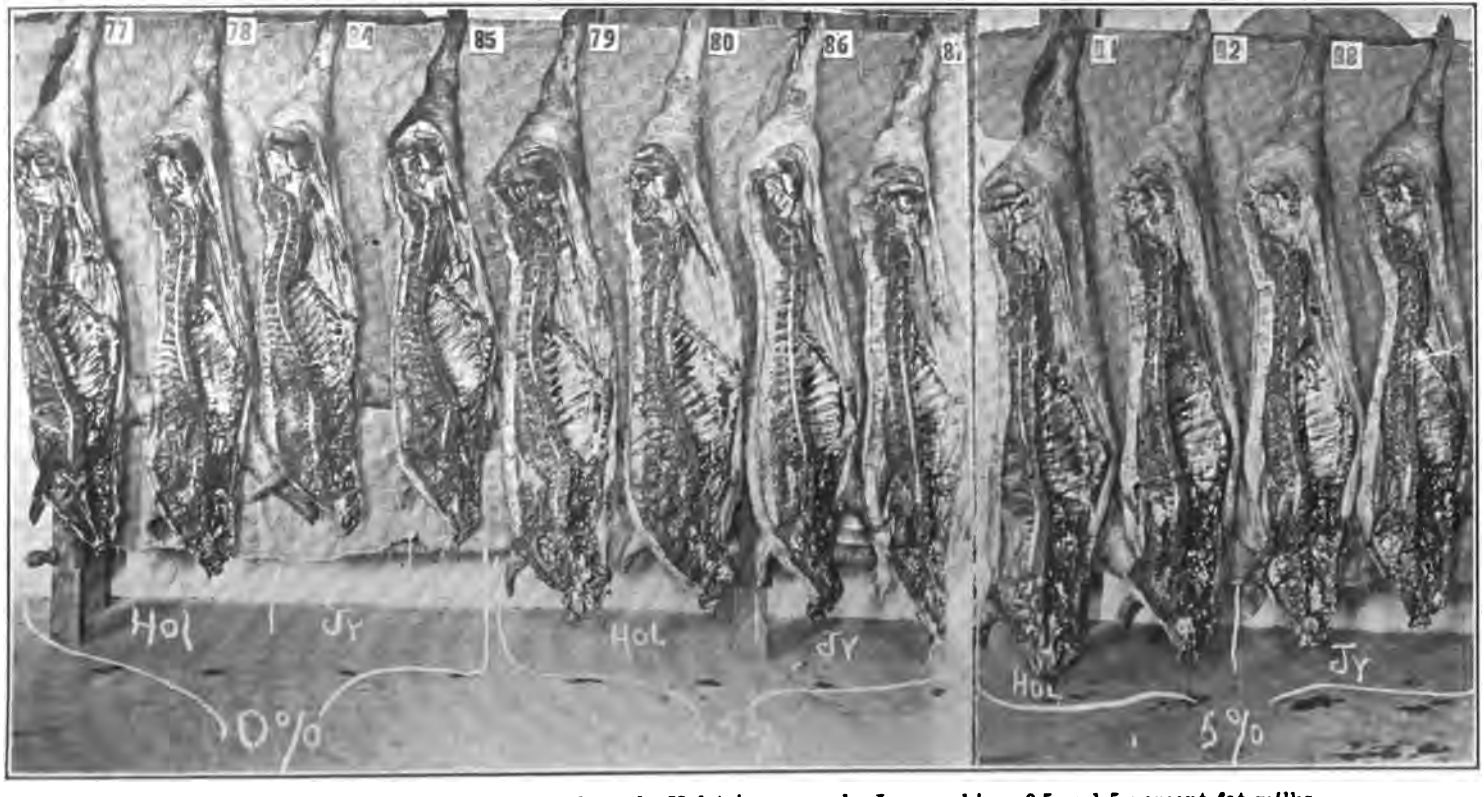


PLATE II. Cross sections of pigs fed grade Holstein or grade Jersey skim-, 2.5 and 5 percent fat milks.

Normal milk | Homogenized milk | Homogenized skimmilk and corn oil

PLATE III. Cross sections of pigs fed normal and homogenized milk and homogenized skimmilk and corn oil.

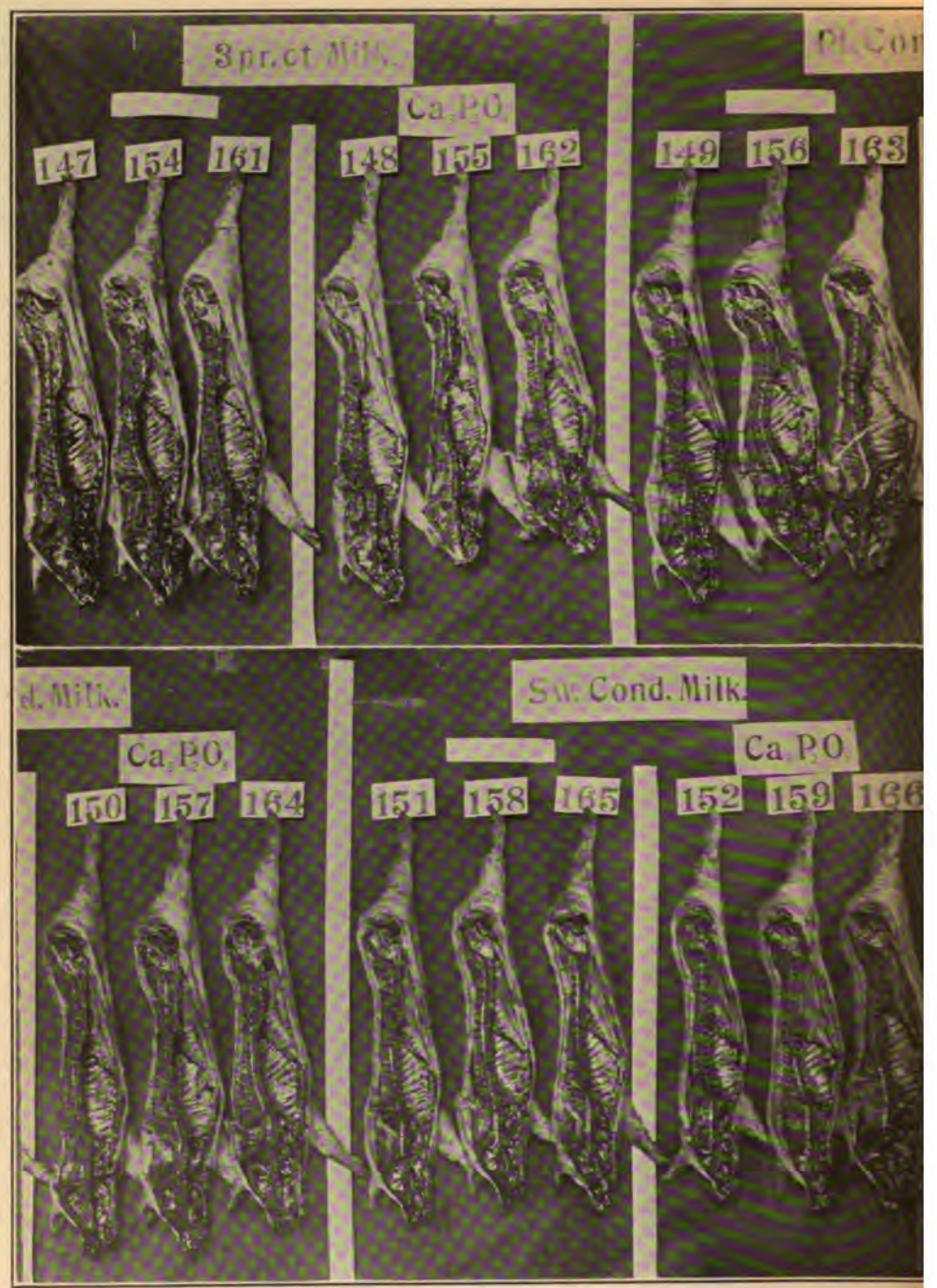


PLATE IV. Cross sections of six pigs fed normal 3 percent milk, six fed unsweetene evaporated milk and six fed sweetened condensed milk. To the right hand three i each case calcium phosphate was fed; to the left hand three in each case no calciu phosphate was fed.

and also in the dry matter, were related rightly to the fat in the food consumed, but they were far below the results attained with the animals fed with milk homogenized at 85° F. instead of at 185° F.

The following table making direct comparison of the ratios of the food nutrients and the body gains is significant.

RATIOS

	In food consumed				In gain	
	Protein	Milk sugar	Fat	Protein	Fat
Normal 2.5 percent milk.....	1 :	1.3 :	1.8	1 :	3.3
Homogenized 2.5 percent....	1 :	1.3 :	1.4	1 :	3.9
Normal 5 percent milk.....	1 :	1.3 :	3.4	1 :	3.6
Homogenized 5 percent.....	1 :	1.3 :	2.7	1 :	3.2
Normal 8 percent milk.....	1 :	1.3 :	5.4	1 :	7.8
Homogenized 8 percent.....	1 :	1.3 :	4.3	1 :	7.2
Normal	1 :	1.3 :	4.4	1 :	2.9
Homogenized	1 :	1.3 :	2.9	1 :	1.9

Such differences as occur in the ratio of the constituents in the food are found mainly in the fat column; hence those occurring in the body gain must be due chiefly to the fat consumed. Thus, comparing normal 2.5 percent with normal 8 percent milk, it appears that the explanation of the ratios 1 : 1.8 and 1 : 5.4 in the fat column are to be found in the protein to fat variation in the added body tissue of 1 : 3.3 and 1 : 7.8 respectively. The 1 : 7.8 ratio indicates excessive fat deposition, and the general vitality of the animals betrayed this condition. Similar comparisons may be made between other members of these groups.

CONCLUSIONS

1. The homogenization of the fat does not seem to be helpful in the feeding of the young, if we may judge by the clinical evidences. The pigs fed the milks thus treated ate their food less greedily and, whenever the fat content of their ration was increased, went "off feed" more quickly than did those receiving milk containing normal fat. However, the curds formed from milk the casein of which had been homogenized were made so much more flocculent and friable as a result of this process that the writers are led to feel that perhaps benefit may be expected from such treatment.

2. The quantity of fat fed is of much more importance in the construction of body tissue than is the size of the fat globules.

3. The effects of homogenization are more noticeable when medium amounts of fat—2 to 3 percent—are fed than when larger

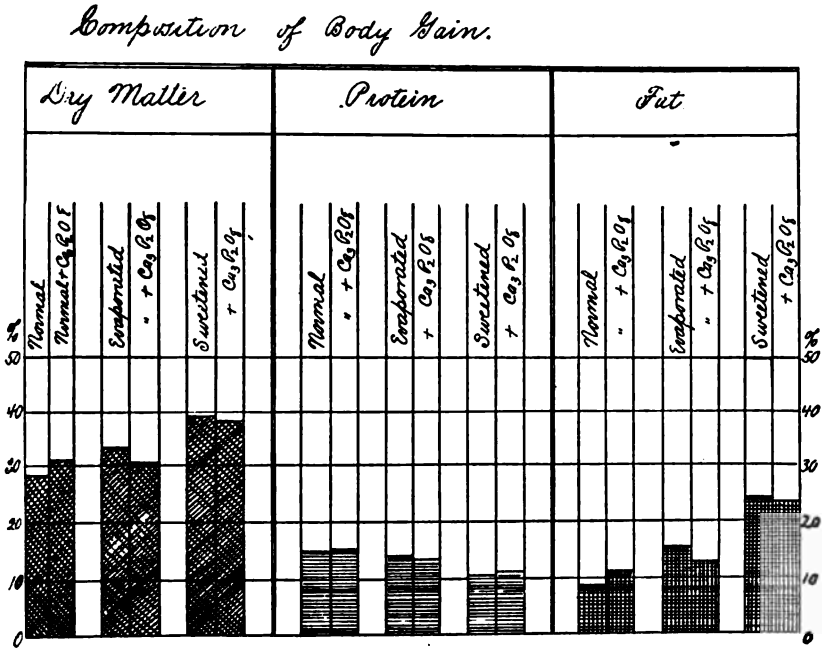
quantities are furnished. Under these conditions there appears to be a slightly increased fat utilization favoring homogenization.

EVAPORATED AND SWEETENED CONDENSED MILKS

These tests were conducted with the purpose of determining the food values of evaporated and sweetened condensed milks when employed as food for the young. This was a very satisfactory trial. The food consumption was quite uniform and the compositions of the normal and evaporated milks were essentially alike. Of course the total solid and (cane) sugar contents of the sweetened condensed milk were increased whereas its protein and fat contents were decreased as compared with those in the milks with which it was in competition. The nutritive ratios of the three milks were 1 : 3.52, 1 : 3.96 and 1 : 8.65, the latter being high on account of its cane sugar content. The ratios of protein to fat in the three milks were much the same, but the contents of protein and ash in the sweetened condensed milk were relatively deficient. The normal milk contained 0.7 percent ash and 3.5 percent protein whereas the sweetened product carried only 0.3 percent ash and 1.6 percent protein. These deficiencies, as well as the shortage in fat, are due to the use of large amounts of cane sugar by the manufacturers in the interests of the preservation of the product. They are betrayed in the 9.8 percent milk- and cane sugar contents of the sweetened products, nearly double those of the other two milks.

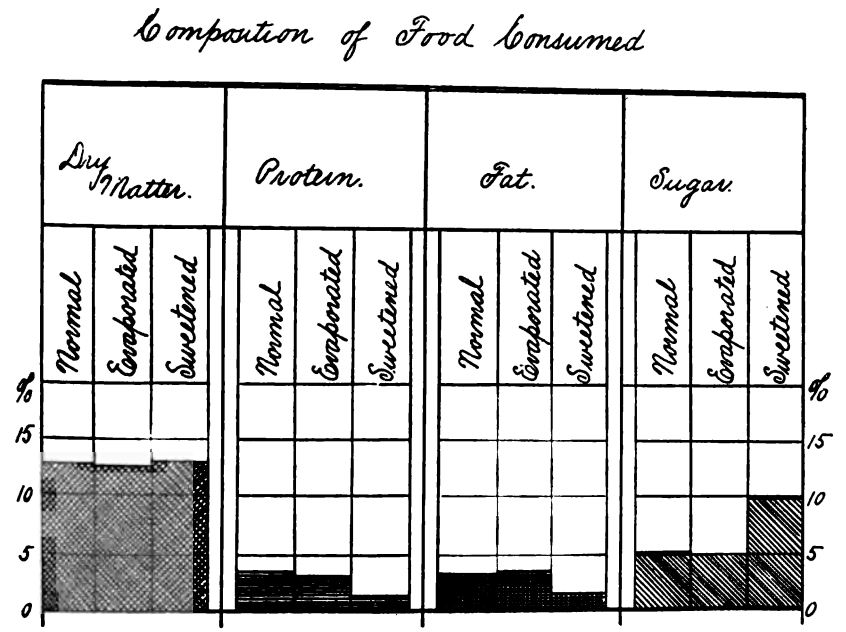
The pigs fed normal, evaporated and sweetened condensed milks gained daily in live weight about 8, 9 and 6 ounces, their dry matter gains being about 2½, 3 and 2½ ounces. The nutritive ratios of the rations were 1 : 3.5, 1 : 4 and 1 : 8.7 and the ratios of protein to fat in the gains were clearly affected by the nature of the food in each case being 1 : 0.64, 1 : 1.03 and 1 : 2.16.

Graph 4, "Composition of body gain," shows that those animals which consumed the sweetened milk made the most dry matter gain, which, however, carried a low protein and a large fat content. A lessened dry matter content with increased protein and reduced fat percentages, a more desirable combination for growing animals, followed the use of normal and evaporated milks.



GRAPH 4

Graph 5 shows the composition of the rations which were fed. The total dry matter consumption in each ration was essentially identi-



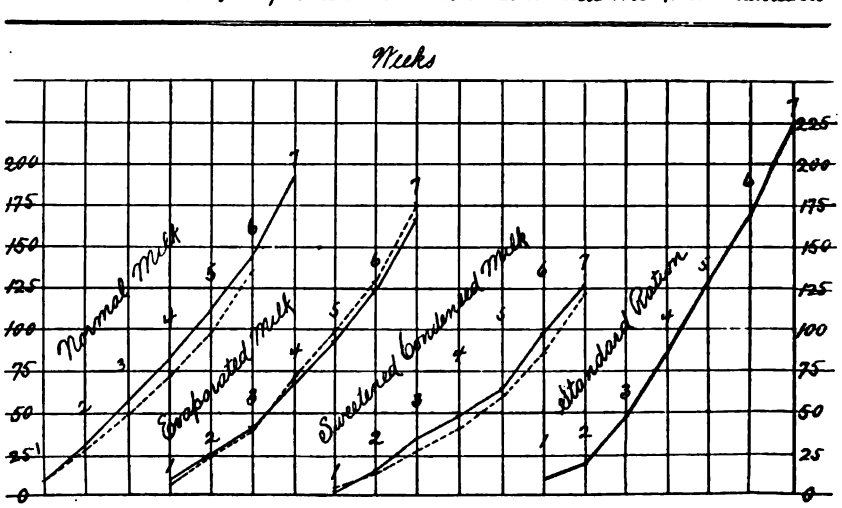
GRAPH 5

cal. The protein, fat and milk sugar contents of the normal and evaporated milks were closely alike, but the fat and protein contents dropped and that of the sugar was raised in the sweetened product.

These graphs illustrate the fact that a fat but weak infant may be expected when sweetened condensed milk is consumed for any material length of time. Surely it is more than a coincidence that the bodies of those animals which received the sweetened condensed milk contain the largest amount of fat, while those receiving the rations containing the higher protein content stored in their bodies correspondingly larger amounts of muscular tissue.

Photographs of longitudinal sections of representative animals fed these three milks appear in Plate IV. A study of these pictures will show that those animals which ate normal milk of medium fat grade were superior physically to those fed sweetened condensed milk, but that they were not materially superior to those which consumed evaporated milk. Those which received sweetened condensed milk containing little protein and much sugar, manifestly were inferior.

A study of the weight lines represented in graph 6 clearly shows that the six pigs consuming normal milk gained more rapidly than those in either of the other two groups, and that the sweetened condensed lot made perceptibly the least and slowest gains. A statement of the average gain made by the pigs fed a standard ration is included with this group for purposes of comparison.



GRAPH 6

The protein, milk sugar and fat ratios in the food consumed compared with the protein to fat ratios in the gains are shown herewith.

RATIOS

	In food consumed				In gain	
	Protein	Milk sugar	Fat	Protein		Fat
Normal milk	1 :	1.4 :	2.1	1	:	1.4
Evaporated milk	1 :	1.5 :	2.4	1	:	2.3
Sweetened condensed milk..	1 :	6.4 :	2.4	1	:	4.85

The wide nutritive ratio of the sweetened condensed milk, due to the addition of cane sugar, is plainly evident, and the character of the resulting tissue is made apparent by the protein to fat ratio.

It should not be inferred that the writers underestimate the value of sweetened condensed milk. It possesses much food value. Undoubtedly it serves an admirable purpose as a source of heat energy in more mature life and probably contains a sufficiency of protein for its maintenance. They hold, however, that it is not well adapted to the indiscriminate feeding of young, growing animals, including the human. A body frame well covered with muscle and not overburdened with fat should be the object sought in feeding the young of any species. Neither this nor any other milk food with a similarly wide nutritive ratio, 1 : 8.5, is suited for use at this early period of development. The writers' personal observations on this point, it may be well to state, are not confined to the study of the records of these pigs but include as well a survey of its use in infant feeding.

CONCLUSIONS

1. Both evaporated milk and sweetened condensed milk are digested readily and assimilated and their nutrients appropriated for tissue growth.

2. Evaporated milk compared very favorably indeed with normal milk standardized to a medium fat percentage, in nutriment and in tissue production.

3. In the trials now under consideration sweetened condensed milk, though showing an abundant nutritive efficiency as measured by energy units, proved an undesirable food for the growing young, for the reason that its nutrients are proportioned so as to produce a weak and dangerously fat body.

FOOD EFFECTS ON SKELETAL STRUCTURE

The question of the effect of food upon the strength of the bone of any animal is of vital interest, particularly because of its relation to rickets and other evidences of malnutrition in children.

CONCERNING RICKETS

During the experimental trials it was observed that under certain conditions the pigs developed lameness or showed an indisposition to remain standing. Farmers of the Middle West long have known that over-fat and weak animals are produced when corn is their sole diet. Some of our experimental animals consuming milk which, like corn, is rich in its carbohydrate and fat contents but relatively poor in ash and protein, developed a condition resembling rickets. Realizing the primary need of a strong body framework and that such can be produced only from the ash in the food consumed, the amount of ash in the ration was increased by the addition of calcium phosphate in order to note its effect on animal composition and bone strength.

Rickets, a disturbance of early childhood, is a condition resulting from malnutrition of the bones. This disease is thought to be more prevalent now than formerly. If a child reaches the age at which it can utilize solid food without developing this malady, its liability to an attack is slight, but no animal at any age seems entirely immune from it.

High fat foods tend to induce a rachitic condition as well as constipation. The disease is more prevalent among bottle-fed babies than among those fed naturally, most cases occurring during the first three or six months of a child's life, the symptoms gradually disappearing as the child becomes able to digest solid food.

The record of the breaking strength of the several femur bones of the pigs fed the normal, the evaporated and sweetened condensed milks was secured. To the ration of some of these animals tri-calcic phosphate was added, with a view of attempting to strengthen the bone structure. The results afford a striking evidence not only as to the effect of a shortened ash supply when the sweetened condensed milk was fed as compared with the other rations, but also of the effect of the addition of calcium phosphate. The bones when normal milk was fed broke under 297 pounds weight; when evaporated milk was fed under 263 pounds weight; when sweetened condensed milk was fed under 200 pounds weight.

CONCLUSIONS

1. The femur of the average pig fed sweetened condensed milk was but two-thirds as strong as that formed when normal milk was fed.

2. Only a slight difference appeared between the normal and the evaporated milk groups in regard to the breaking strength of their femurs, but this difference favored the normal product.

3. In spite of the high ash percentage utilization by the pigs fed sweetened condensed milk, their body gain contained less ash than did the gains of either the normal or the evaporated-milk-fed-animals.

DILUTE OR CONCENTRATED RATIONS

It was noted that those pigs which ate the relatively dilute skimmilk gained less rapidly in weight and retained a smaller percentage of the food units they consumed than did the animals fed milks of medium and high fat contents; and the question naturally arose whether this was or was not due to the dilute nature of the skimmilk ration.

The effect of dilution on the utilization of protein, milk sugar and fat is a pertinent matter. It is evident that a larger bulk of a dilute food must be consumed in order to secure a given amount of dry matter than of a more concentrated ration. Will increased dilution tend to prevent the consumption of an amount of food sufficient to produce normal body growth? Will an excessive amount of water cause a reduction in food utilization?

The results of the trials were not in all respects as conclusive as might be wished. Furthermore, this special phase of the subject is under further study at the present writing. Consequently the conclusions only for the larger bulletin are presented as follows:

CONCLUSIONS

1. The theory that the ingestion of more water than is needed tends to lessen the food value of a ration seems sound.

2. In view of the fact that the milks were not heavily diluted, the writers do not feel justified in speculating as to what might have happened had an excessive amount of water been added to a milk of a medium fat content.

3. The results of these limited trials, while indicative, do not warrant definite conclusions.

HUMAN MILK AND COWS' MILK

It is well known that the milk of a healthy mother is the best food for her infant. Many mothers, however, are unable to nurse their babes and recourse must be had to cows' milk. Now the milk of one species is not necessarily adapted to the nourishment of the young of another species. Great differences in comparative development exist at birth among the several classes of animals. Some develop in a few months, while others, especially the human, live for a time in

helpless infancy and require years to reach maturity. The feeling that in the mother's milk nature provides the best food for the young of any species, is unquestionably well founded. But when the human mother is unable to nurse her offspring and a wet nurse cannot be had the milk of the cow, suitably modified, must be used for nourishment. How shall it be modified? What standard shall be adopted?

The composition of human milk has long been studied, usually, however, in a disconnected sort of way. The results reported by the many analysts differ widely. Thus ten analysts report fat percentages from 2.7 to 4, protein 1.4 to 2.1, milk sugar from 5 to 7.4 and ash from 0.2 to 0.4. Richmond states that minima and maxima are 0.5 to 9.1, 0.9 to 5.6, 4.2 to 8.9 and 0.1 to 0.5. Forty samples representing the milk flow of twenty women, some well, some ill, some whose babies were thriving and some ailing, were collected and analyzed in connection with this study, careful clinical observations being made at the same time. These vary as follows: 0.6 to 8.6 percent fat, 1 to 2 percent protein, 5.5 to 7.8 percent milk sugar, 0.1 to 0.2 percent ash, and the lowest total solid content was 9.9 and the highest 14.7 percent.

Human milk, like cows' milk, varies greatly and in much the same way. The first milk drawn from the breast of the woman or the udder of the cow is usually poor in fat, while the last which is drawn is comparatively rich in fat; but the sugar and protein contents of the foremilk and of the last drafts from the gland are essentially alike. The milk of a nervous woman or of an excitable cow is apt to be small in amount but rich in fat. Temporary excitement and fatigue also tend to increase the fat content. Obvious difficulties exist when one attempts adequately to sample human milk. A cow is milked twice daily and the udder is emptied. The woman nurses her child frequently and the complete emptying of the breast, in the same sense that a cow's udder is emptied, is not easily done. Doubtless many samples of human milk, the analyses of which appear in literature, as a matter of fact were not accurately representative of the entire product of the breast. Clearly no group of figures can be secured which with certainty will represent the "average" composition of woman's milk.

In order to modify cows' milk for the purpose of infant feeding and to obtain uniformity in the product thus modified, some standard procedure must be used. What should this be? Should the results attained from the analyses of the milk given by sick mothers, or by those who experience difficulty in nursing, or the results attained from inadequate samples, be used in the determination of this standard?

Should these milks be included in an "average"? An average analysis is not pertinent, but, rather, a knowledge of what grade of milk best agrees with the child and is most likely to produce a strong, vigorous, healthy individual; but not the greatest growth as measured by gain in weight. With this information as a working basis, the writers, as a result of their work and study, favor the use of a modified milk lower in fat and higher in protein than is usually employed.

It is well known that cows' milk varies greatly in composition, that breed, period of lactation, bodily condition and many other factors affect it. Dairymen know that either fatigue or excitation tend to increase for the time being the fat content of milk. The relatively quiet Holstein and the relatively placid negress yield milk carrying a moderate fat content, while the nervous Jersey and the excitable woman, over-fed, over-worked or society-worn, yield milk relatively rich in fat. The writers have found a seven percent fat content in a mother's milk when she was tired and nervous, although its normal fat content was only four percent; and the previously healthy babe was quickly out of condition.

Differences are recognized other than those in chemical composition between the milk of woman and of the cow. Space does not permit their full discussion. However, mention should be made of the character of their curds when acted upon by pepsin or rennin. Cows' milk coagulates into a firm, rather solid, rubbery, curd mass, while that of the woman forms a flocculent precipitate. This physical difference may have an important bearing upon digestibilities.

SYSTEMS OF INFANT FEEDING

Infants fed cows' milk often void white, curd-like clots and masses which have been thought to be coagulated but undigested curd or casein. Such children are likely to be somewhat unthrifty and often are subject to colic. The idea that this condition was brought about by an inability to digest the casein of cows' milk became a conviction in the minds of many medical practitioners and gave rise to the so-called percentage or "American" system of milk modification.

The "American system," which is quite generally followed in this country, aims to modify cows' milk in order to conform to a standard measured by an assumed composition of human milk. Water then is added in order to reduce its casein content, which naturally decreases the content of the other nutrients as well; cream is added to reestablish the grade of fat assumed to be typical for human milk; and the milk

sugar percentage is reinforced by the addition of some form of sugar. Since cane sugar readily ferments, milk sugar or a dextrin-maltose compound are commonly employed for this purpose.

Since the presence of water retards the coagulation of milk outside the stomach, it is reasonable to suppose that it does so within the stomach. However, the curd mass formed from watered milk is nearly if not quite as firm as that formed from undiluted milk. In order to obviate to some extent the formation of this hard curd, either barley, or oatmeal water is often used to reduce the milk, together with small quantities of lime water which tends to act as a corrective.

The German or calorific system of feeding was devised by Heubner, who worked out a ratio between the number of units of energy to be received daily and the weight of the child consuming the milk. His experience, which covered many cases, led him to state that the young child should receive daily not more than 100 Calories of energy per kilogram of body weight during the first three months, usually not more than 90 during the second three months, and 80 or less thereafter, the energy to be derived from medium fat milk.

It is generally believed that the "percentage" system of feeding young infants produces better results than the consumption of undiluted cows' milk, yet overfat and rachitic infants abound, even when thus fed. The German school holds that the vital point in infant nutrition is the energy quotient. The American school stresses the idea that the composition of the milk should be modified to simulate average human milk. The writers hold, however, that neither system is complete; that the ratio of ash to protein and the ratio of ash and protein to the energy consumed should be taken into consideration; that while the production of muscular tissue and fat are important, the building of a strong skeletal structure is also a vital matter. The importance of the ash content of a ration in bone building has been realized for years; yet many writers on nutrition dispose of the matter with but a casual paragraph.

A COMBINED SYSTEM

There is nothing, however, really incompatible between the American and German systems of infant feeding. Each possesses merit. It seems to the writers the part of wisdom to make a selective combination. To this end the writers suggest such a combined system, one which retains the percentage statement of the one and the Calorie dictums of the other, one which lowers the high fat percentage usually prescribed by the American system, thereby diminishing the ratio be-

tween the protein, carbohydrates and fat, and specifies that from one-third to one-fourth of the Calories fed be derived from protein, one-third from fat and the remainder from milk sugar and dextrin-maltose. It appears to the writers that the tendency when using either system seems to be in the direction of an excessive use of fat, since this nutrient may be easily regulated to obtain any desired number of Calories. However, the protein and sugar contents should be proportionally raised so that the nutritive ratio will not be too largely augmented. Many infant troubles of a digestive nature result from overfeeding early in life, and the fat is most apt to be the disturbing factor.

No hard and fast rule can be formulated applicable to all cases of infant nutrition. The writers suggest in lieu thereof a milk standard which it is believed should serve as a satisfactory base ration, one which, with simple dilution with water or gruel and the addition of milk sugar or dextrin-maltose, will furnish proper nourishment for the normal human infant. They feel that if directions are followed it will be impossible greatly to overfeed with fat, and that, as a result, the evils attendant upon the overconsumption of fat, e. g., dyspeptic hunger, colic, constipation and eczema, will be minimized. They are convinced that protein is rarely the disturbing nutrient and believe that no rational grounds exist for the general practise of feeding a human infant a diet low in mineral matter and protein and excessively rich in sugar and fat.

Of course under normal conditions artificial feeding should never replace breast feeding. Whenever possible the latter should be encouraged. It is better to supplement a scanty breast milk supply by small artificial feedings than to discard it entirely. It may often be well to resort to "complemental feeding," the substitution of one or more feedings of a modified milk for a corresponding number of breast feedings; or to attempt "supplemental feeding, putting the infant to the breast for a certain period, after which the infant is given a bottle of modified milk and allowed to nurse until satisfied."

It seems inadvisable to attempt to feed the Calorie requirement of the German standard during the first few weeks after birth, but rather to encourage a gradual tolerance for artificial food, thus inducing relatively moderate initial gains, ultimately reaching the requirement of 40 Calories per pound of weight. The German system aids one in determining whether or not an infant is being overfed. It is then pertinent to discover whether the digestive disturbances are due to the fat or the sugar contents of the ration. Poor tolerance for milk

sugar is indicated by thin, watery stools while excessive fat consumption is manifested in either a soapy or a hard, dry stool.

Directions for infant feeding to be practical must be simply stated and the routine of food preparation must be such that the mother or nurse can follow it with exactness and dispatch. With these limitations in view the writers suggest the following procedure.

In order to produce a milk food likely to be adapted to the uses of the normal human infant, the quart bottle of approximately 4 percent milk, such as is generally obtainable from the local milk dealer, is selected. It is, of course, presupposed that, as far as may be, due care is exercised to insure the healthfulness and cleanliness of the supply. It should stand from 3 to 4 hours or more in order to allow the cream to rise. Under usual conditions this occasions no delay since milk from the previous night's supply is already in suitable condition and the morning's milk is bottled an hour or two before delivery.

The top two ounces are removed, using a suitable spoon or dipper, and the remaining 30 ounces mixed by pouring from one bottle to another. The milk would then contain approximately: Water 88.4 percent, ash 0.7 percent, protein 3.7 percent, milk sugar 4.7 percent, fat 2.5 percent. Its nutritive ratio will be about 1 : 2.8 and it will contain 18 Calories per ounce, approximately 4.6 of which are derived from the protein, 6 from the milk sugar and 7.4 from fat.[1]

The milk is now ready for dilution with water—preferably boiled —or gruel, and for an addition of either dextrin-maltose or milk sugar in quantity enough to make the sugar content of the diluted mixture approximately 6 percent.

In the statement of general directions which follow, the writers have drawn freely upon material in the many volumes published on infant feeding, especially Grulee, and have simply recommended the special standard milk just described.

Factors to be Considered in Infant Feeding

A general rule governing the amount to be offered at each feeding may be stated as follows: Offer the child as many ounces as he is months old plus one to one and a half.

[1] The Calories per ounce may be readily calculated with approximate accuracy using any milk analysis, as follows:
Calories per ounce = [(Fat × 2¼) + protein + milk sugar] × 1¼.
Thus in the case above cited:
(2.5 × 2¼ = 5.63) + 3.7 + 4.71 = 14.03.
14.03 × 1¼ = 17.5.
It should be noted that each percent of fat in milk is equivalent to approximately 8 Calories per ounce; each percent of protein or milk sugar, to approximately 1¼ Calories per ounce; and one ounce or three tablespoonfuls of dextrin-maltose or milk sugar, to approximately 120 Calories.

In the first place it should be clearly understood that the first three months of a child's life is a critical period. A large gain in weight is neither important nor desirable. One should seek rather to avoid nutritional disturbances and to maintain health and vigor. Water, and that only, should be given the first day or two after birth, at intervals of from three to four hours and in two-ounce portions. This may be followed with three-ounce feedings of a milk and water mixture, equal parts of each. Later, up to two months and over, the amounts of this food offered at each feeding may be gradually increased until four to five ounces are fed; and these may be fortified by adding either dextrin-maltose or milk sugar in the proportion of one to two level tablespoonfuls to the entire daily mixture.

After the child reaches the age of three months, a milk modified according to the formula above indicated may prove serviceable in the feeding of a normal infant as set forth in the following statements. Obviously the *age and weight* of the child are factors to be considered in determining the amounts to be fed. The capacity of its stomach, the number of daily feedings and the intervals between them are in the main dependent upon its age; and the amount of nutrients needed for maintenance and growth are similarly dependent upon its weight. The following table indicates some of these items.

Age	Capacity of stomach	Suggested feedings	Interval between feedings
At birth	1½ to 2 ounces	8 per day	3 hours
Three months	4½ ounces	5 to 6 per day	4 hours
Six months	6 ounces	5 per day	4 hours
Eight months	7 ounces	5 per day	4 hours
Ten months	8 ounces	4 per day	4 hours
Twelve months	9 ounces	4 per day	4 hours

A. The ounces of food offered daily will equal the stomach capacity multiplied by the number of daily feedings.

B. The child's weight in pounds multiplied by one and a half equals the number of ounces of milk which should furnish enough protein for maintenance and growth.

C. Subtracting the result of the second multiplication (B) from that of the first (A) gives the ounces of water needed to dilute the milk for a day's feeding.

$$A - B = C.$$

The daily ration thus made may be fortified by the addition of three level tablespoonfuls either of dextrin-maltose or milk sugar. When the child is old enough to utilize undiluted milk, one tablespoonful or less of dextrin-maltose or milk sugar will suffice.

An example may serve to make this procedure more clear.

Child 3 months old, weight 12 pounds. Stomach capacity 4.5 ounces, 6 daily feedings.

$$4\frac{1}{2} \times 6 = 27 \text{ ounces A}$$
$$12 \times 1\frac{1}{2} = 18 \text{ ounces B}$$
$$\text{Water} = 9 \text{ ounces}$$

Use 18 ounces of milk from the 30 ounces left in a quart bottle after the two top ounces of cream have been removed; add 9 ounces of water and from 2½ to 3 level tablespoonfuls either of dextrin-maltose or milk sugar and mix thoroughly.

It is, of course, understood that no single milk formula is universally applicable; that every little infant stomach is a private experiment station; that the system above outlined is suggestive only. There is this much to be said about it, however, that it has been used in actual pediatric practice with excellent results.

It is important that one distinguish clearly between the immediate effect of a food as shown by the readiness and completeness of its digestion, which is often determined by the individuality of the child, and the more permanent effect as shown by the character of the tissue which is formed. A food must "agree with" a child; yet a food which may agree—that is to say may digest without immediate ill-effect—may be of such a character as in time to produce abnormal growth. Clearly it is an important matter that the food shall not only agree temporarily, and of course ultimately, but that its chemical composition shall be such that its nutrients exist in the right proportion to build sound and healthy tissue. The former condition depends but little upon food composition, the latter is greatly concerned with it.

A food may not agree with a child for the time being, may indeed act almost as does a poison, yet if its use is discontinued for a time and then gradually and carefully reestablished, a tolerance may be developed which will allow it to be continually and satisfactorily fed. Whether a child can or cannot tolerate a food is due primarily to its individuality, but the character of the body gain resulting from the consumption of a given food depends upon the food itself.

The thinner milks more economical. Although the rearing of infants at low cost should not be and is not a matter of first importance, yet it is a matter which is worthy of serious consideration. Recent studies have shown that the less expensive milk foods containing a reduced fat percentage have produced stronger and more healthy children than have more costly rations. Butter fat in the form of cream

is worth at different seasons of the year from 30 to about 50 cents a pound. If a 4 percent milk is bought for 8 cents per quart, its non-fatty constituents, which produce the stronger infant, are costing not more than 25 cents per pound, or one-half the higher price paid for fat.

Milk not only furnishes a highly valuable food, but also it favorably influences the digestibility of the other foods consumed along with it. For this reason, among others, children under five years of age ordinarily should be encouraged to consume moderate quantities of milk provided it has been made and kept in a cleanly way. During this period especially a milk of medium or low fat content but rich in ash and protein is to be preferred. Plain skimmilk might best suit the needs of hearty eaters showing a tendency toward overfatness, while perhaps a richer milk might be fed to the child which has passed infancy and requires additional energy.

OVERFEEDING

It is stated elsewhere that certain systems of infant feeding which have enjoyed wide vogue employ relatively high fat formulas. There seems reason to believe that many infants are overdosed with fat, that many of them eat too much, that fat cheeks are not of necessity an evidence of bodily health. An animal's appetite is not always a trustworthy index to the quantity of food it needs.

Bearing in mind these facts brought out by animal experimentation, the writers have closely observed the eating habits of young children. They are convinced that many are permitted, indeed encouraged, to eat more than they can properly utilize and this, too, whether breast-fed or artificially nourished. Such children would be more healthy, less peevish, better able to resist infection, if they ate less. It were better in warm weather to under-feed than to over-feed.

The high-fat theory of milk modification is found throughout American pediatric and dietetic literature. Its justification appears to rest upon the supposition that human milk contains a considerable amount of fat. However, an incorrect standard is often adopted, a standard which carries too much fat in proportion to protein. Although many samples of woman's milk given by sick, nervous or overfed mothers, contain from 3.5 percent to 4.5 percent fat or even more, it does not follow that a high fat content is best for the growing child, nor that the milk of mothers who are rearing strong babes will show so high a fat content. The vigorous colored women of the South as a rule are good wet nurses and the fat content in their milk is low, varying of course but averaging hardly 3 percent. It is also known that

the first milk drawn from the breast carries far less fat than does the later portion, a difference particularly marked in the case of women with full breasts. With such a nurse the child does not draw all the milk at any one feeding and, therefore, secures milk containing a lower fat content than the average for that particular woman. Children reared at such a breast do well if not allowed to consume too much. When, however, the fat content of a substitute for mother's milk is rather high and little or no check is made on the amount consumed, there is great danger of overfeeding.

Authorities state that overfeeding is so prevalent in this country that it is the rule; that it is second to no other factor as a cause of infant illness; that its results are easily recognizable; that to feed rationally it is necessary to know how much food the baby is getting in proportion to its weight; that the disturbing element in overfeeding with cows' milk is the fat, which eaten in excessive amounts regularly produces constipation.

The evidences of overfeeding are: a too rapid gain in weight followed by irritability, restlessness and broken sleep followed by constipation. The feces, heretofore of normal odor and color, are apt to become pale gray, hard and dry, while their odor is strong and suggestive of decomposition. Sweating about the head and rapid respiration are also indicative and such skin eruptions as eczema and boils are apt to occur. A careful examination of the infant's stools affords valuable evidence as to the completeness of digestion. Some doctors say that they "would much prefer to see the stool than the infant if both could not be seen."

There is plenty of evidence at hand indicating the folly of loading an infant's food with fat on the theory that the child requires it. Indeed infants are being successfully reared on buttermilk containing practically no fat. In fact, fat as such is not essential to the life or growth of the child, and an excess is a detriment since it causes diarrhoea, constipation and all their consequent ills as well as aggravating rachitic conditions. In view of the fact that our own experimental findings covering a period of several years and including as subjects 162 baby pigs, clearly show that rich milk is not tolerated by pigs as well as is milk containing a smaller quantity of fat, we are inclined to hold with many eminent pediatrists that a high fat percentage of milk for infants is not necessary but, rather, is harmful.

Several specialists in infant feeding now employ a more rational system than the top-milk, high-fat one, a system much like that suggested on pages 28 to 30. It is believed that the practice is extending.

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MARCH, 1917 BULLETIN 202

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

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"MONY MEIKLES MAK A MUCKLE" II

I. The Relation of the Milk-Vein System to Production,
by A. W. Aldrich and J. W. Dana.

II. The Cost of Production of Milk and Butterfat in 1911 and 1912,
by G. M. Nelson.

III. The Effect of the Sire on the Herd,
by J. H. Wilson.

IV. Concerning the Burlington Milk Supply,
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Bulletin 170 was constructed from ten short articles, totaling 17 pages. It was said in the foreword of that bulletin that "no one of them is big enough to make a bulletin, yet in several of them, it is thought, there is material worthy of record." The same may be said of the eleven articles printed in this issue and in its immediate successor, No. 203. In each case the article represents a brief of a thesis —or theses—presented by graduates of the College of Agriculture of the University of Vermont in partial fulfillment of graduation requirements.

The briefs in each case have been made by the writer of this note, in consultation with his associates in whose several departments the work was orginally carried on. In all cases the matter as originally presented has been recast. Indeed, the language of the briefs is very largely that of the writer of this note. In all cases where the deductions rested upon mathematical data, they have been checked as to accuracy.

JOSEPH L. HILLS, Director.

THE RELATION OF THE MILK-VEIN SYSTEM OF DAIRY ANIMALS TO PRODUCTION

BY A. W. ALDRICH AND J. W. DANA

The score cards of the several dairy cattle breeders' associations take cognizance of the character of the so-called mammary or "milk-veins," according from four to ten points on a scale of 100 to their size, convolutions, etc. The Ayrshire score card allows five points to "large, long, tortuous, branching milk-veins entering large orifices";

the Guernsey card eight counts to "long, crooked, branching and prominent milk-veins with large or deep wells"; the Holstein-Friesian card ten points to "very large, very crooked (age must be taken into consideration in judging of size and crookedness) mammary veins, entering very large or numerous orifices, double extension, with special developments, such as branches, connections, etc."; and the Jersey card four points to "large, long, tortuous and elastic milk-veins entering large and numerous orifices." So far as the so-called "milk-wells" are concerned, the Ayrshire score card calls for "large," the Guernsey for "large or deep," the Holstein-Friesian for "very large or numerous" and the Jersey card for "large and numerous" wells. All four cards recognize the desirability of "large" and "crooked" veins, one of them of "very large" and "very crooked" veins. Elasticity, length and branches are also stressed. Clearly, cattle breeders think that the milk-vein system and productivity are closely related.

Some breeders state that the "more blood, the more milk"; that varicosity is desirable in order that the flow of blood during milking may not be impeded, lest congestion occur and secretory ability become reduced. They claim that milk secretion is directly related to and proportioned to the freedom of the blood flow through the udder, and say that crookedness is Nature's device whereby the stretching of the unelastic veins is permitted; that they grow with the increase of the size of the abdomen and increase in crookedness after each parturition; and that their dilation and lengthening is due to blood pressure. They affirm that the system is the result of a carefully developed capacity to convert food into blood and milk. On the other hand, some of the medical profession object to large milk-veins and sizeable milk-wells, holding that the former are analogous to the dilated or varicose veins of the human body and that they indicate a diseased condition of the circulatory system; that their size, tortuosity and varicosity are due to the pressure of the gravid uterus rather than to other causes.

It would seem worth while to attempt to determine as a matter of fact whether the makers of the score cards are justified in stressing the importance of the so-called milk-vein system; whether any marked and positive correlation exists between its ramifications and dairy production; whether the accumulation of a sufficient number of definite measurements of cows whose productivity is a matter of record might not furnish data for an adequate judgment. Consequently measurements of more than 600 cows were taken and compared with their milk and fat yield records. The milk-vein system observations were made in every case by one or the other of the writers. The production records were secured from the cattle owners, all, save the Uni-

versity, being members of cow test associations. The data were taken in and around Burlington, Pittsford, Hartford and Pomfret.

Let us at the outset attempt to trace the course of the blood supply of the mammary gland. The course of the arterial blood, leaving the heart by way of the aorta, divides under the fifth or sixth lumbar vertebra, forming the internal and external iliacs. The latter descends along the tendon of the psoas minor muscle, becoming the femoral artery at the level of the internal border of the pubis. At the origin of the femoral, the prepubic artery arises and passes forward, inward, and downward to the inner part of the internal inguinal ring, where it divides into the posterior abdominal and external pudic arteries. The latter continues downwards and divides into the subcutaneous abdominal and the mammary arteries. The latter enters the mammary gland. The veinous system which takes the blood from the udder is more complicated. It is collected from 14 to 17 large vessels which empty into the mammary or so-called milk-veins at the base of the gland. The blood departs by way of five veins—two subcutaneous abdominal, two external pudic and the perineal veins. The first named, sometimes called the anterior mammary or milk-veins, start from the front of the udder, pass forward along the outside of the lower wall of the abdomen and through foramens (milk-wells) to join the internal thoracic vein which empties into the anterior vena cava at or near the first rib. The second named, sometimes called the middle mammary or milk-veins, are of considerable size though smaller than the first named, and extend upwards as satellites of the external pudic arteries, joining the externals, which later unite with the internals to form the main iliac veins, each later to unite with its mate under the fifth lumbar vertebra to form the posterior vena cava. The third named, sometimes called the posterior mammary or milk-veins, arising from the rear of the udder, run medially to the perineum, turn around the ischial arch and join the internal pudic vein, which enters the internal iliac and unite with the external iliac.

The course of the blood is, then, as follows: *Arterial;* abdominal aorta, external iliac, prepubic, external pudic, mammary. *Veinous;* mammary, subcutaneous abdominal, internal thoracic, anterior vena cava; or mammary, external pudic, external iliac, common iliac, posterior vena cava; or mammary, perineal, internal pudic, internal iliac, common iliac, posterior vena cava.

Figures 1, 2 and 3 are illustrative of this general system.

Figure 1 is a drawing from a photograph of the right milk-vein of the station cow Sabra, whose record appears on pages 8 and 9. It is a typical subcutaneous, abdominal vein of the ideal sort.

Figure 2 is an attempt to show in one plate all of the different veinous formations which were encountered in the study of the cows

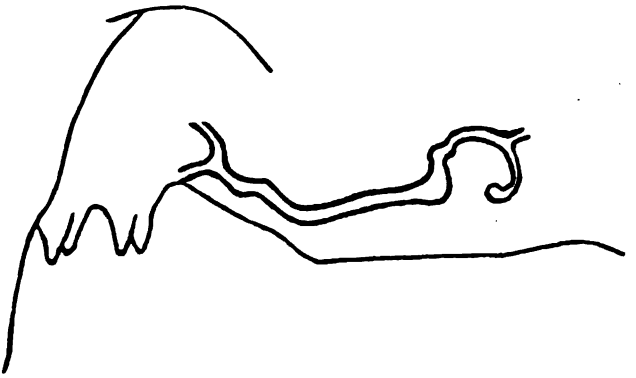


FIG. 1. A typical subcutaneous abdominal milk-vein.

whose records enter into the preparation of this article. Of course no one cow showed all of these manifestations. Nearly one-third of them showed only the main vein (A). The fork (B) was found usually to

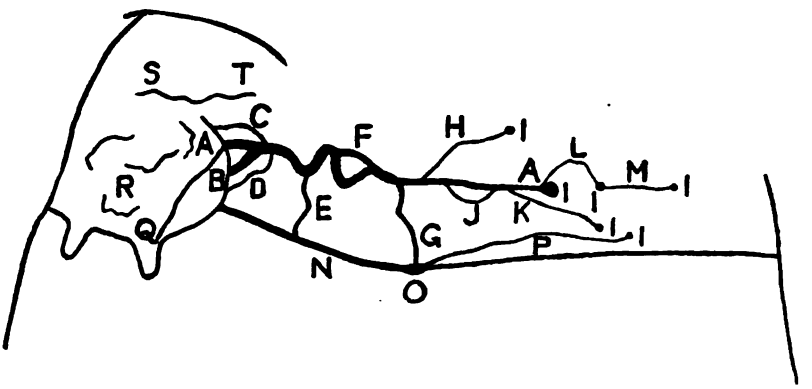


FIG. 2. The sundry types of milk-veins.

be about as long and as large as the corresponding part of the main vein. The lateral (C) and the ventral (D) forks, the former seldom and the latter often occurring, were of small diameter. The connection (E) is usually a small vein joining the main vein (A) and the independent umbilical development (N) or, if the latter is absent, the other main vein. The external branches (F lateral, J ventral) were very much of the same size or smaller than the main vein, usually short, sometimes extending to the orifice of the main vein. Branches may exist which pass through separate orifices and return to the main vein with-

in the body wall, being the umbilical development (G), lateral (H) and ventral (K) branches and abdominal (L) and chest (M) extensions. An independent umbilical development (N) rarely occurs, extending

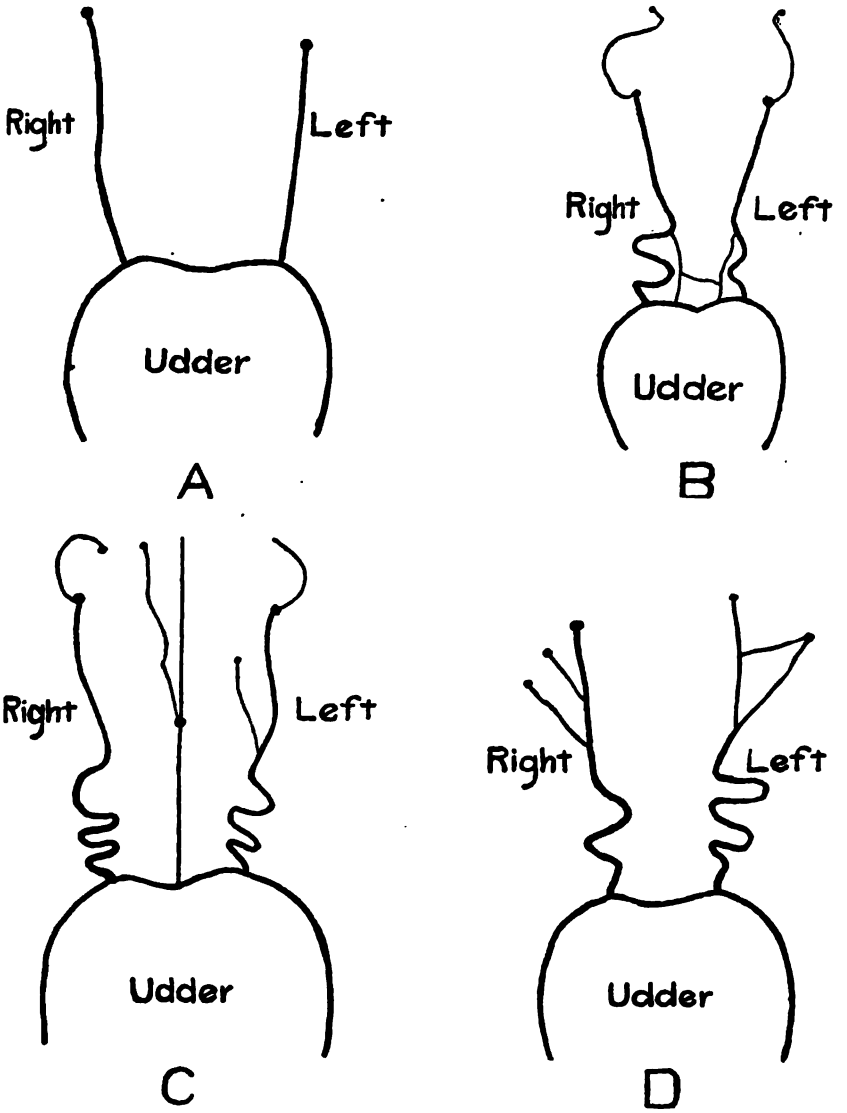


FIG. 3. Sundry forms of milk-veins.

along the center of the abdomen, and entering at the umbilicus (O) or continuing forward along the umbilical extension (P) to another orifice. Veins (R) on the udder surface vary greatly as to size and

number, appearing on less than one-fourth of the cows examined. The teat vein (Q) occasionally extends down the udder to the fore teat. Very rarely there occurs a secondary vein (S), small but prominent and sometimes bearing an extension (T). The milk-wells or foramens, the orifices through which the veins pass back from beneath the skin within the body wall, are generally found at the end of the main vein (A), lateral branches (H), ventral branches (K), abdominal extension (L), chest extension (M) and umbilical extension (P).

Figure 3 gives some idea of the extreme variability of the milk-vein systems of different cows, the point of view being that from underneath the cow, or, in other words, a worm's eye view. A represents the milk-veins of the station cow Phoebe, a high grade Holstein, one of the simplest of milk-vein systems; B, those of Sabra, a high grade Jersey (see figure 1); C, those of a registered Jersey; and D, of a high grade Jersey.

The following tabulation sets forth two typical illustrations of the records taken in the course of this survey: one, Phoebe, on the left, a case where the milk-vein system was extremely simple (figure 3A), and the second, Sabra, a case where the system was somewhat complicated (figure 3B).

Name and address of owner: Vt. Exp. Sta. Burlington. Vt. Exp. Sta. Burlington.

Date of measurements	**February 17, 1913**	**January 3, 1913**
Name of cow	**Phoebe**	**Sabra**
Breed	**Grade Holstein**	**Grade Jersey**
Age	**3 years**	**9 years**
Calved	**January 16, 1913**	**September 29, 1912**
Average yearly yield: milk	**7475 lbs.**	**4132 lbs.**
Average yearly yield: fat	**377 lbs.**	**249 lbs.**
Average fat content	**3.59%**	**6.05%**
Length to udder	**29 inches**	**32 inches**
Length to navel	**21 inches**	**20 inches**

	Left	Right	Left	Right
Length of body, inches.....	57	58	59	60
Shape of fore udder.....	Average	Average	Average	Average
Veins on udder.....	None	None	None	None
Main vein—				
Distance from udder to well, inches	12	13	15.5	15
Length, inches.....	12.5	14	18.5	19.5
Contour.....	Straight	Nearly straight	Very crooked	Very crooked
Diameter, inches.....	16/16 Nearly flat	15/16 Nearly flat	17/16 Fairly prominent	18/16 Fairly prominent
Size of well	2	1	4	7
Shape of well.....	Circular	Circular	Circular	Circular
Depth of well.....	Medium	Medium	Deep	Deep
Variations.....	None	None		
Ventral fork	.....	.....	.....	.....

Distance between extremes, inches	4.5	6
Length, inches	4.5	6
Contour	Nearly straight	Nearly straight
Diameter, inches	12/16	13/16
Size	prominent	prominent
Abdominal extension—		
Distance from udder to well, inches	19.5	20
Length, inches	10	11
Contour	Fairly crooked	Fairly crooked
Diameter, inches	14/16	15/16
Size	Flat	Nearly flat
Size of well	1	1
Shape	Oblong	Circular
Depth	Deep	Medium

Connection between ventral forks—

Distance between extremes	2 inches
Length of connection	2.5 inches
Contour	Nearly straight
Diameter	19/16 inches
Size	Prominent

It should be said concerning the matter of data taking that the yearly milk and fat yields were used for as many years as there were records. In a considerable number of cases the records were for but a single year, either because the cow was young or because records had not been longer kept. In one case a twelve years' average was obtained. The cows were in all stages of lactation, some having just calved, some being in midlactation, while some were drying off. However, several measurements, taken by each of the writers at various times during the lactation period of the same cows, were a unit in declaring that the stage of lactation made no appreciable difference in the measurements.

Four measurements were taken of the length of the animals, using a right angle measuring rod, 18 x 69 inches and a tape measure, in order that their milk-vein lengths might be better compared.

1. The length to the anterior attachment of the udder was taken along the middle line of the body from a point even with the back of the fore legs.

2. The length to the navel was taken from the same point behind the fore legs.

3. The length of the body was taken on the left side from the extremity of the rump—pin bone—to the shoulder point.

4. The length of the body was similarly taken on the right side.

The shape of the fore udder was described as "long" (extending well forward), "average" (medium), and "short" (abbreviated). The

veins on the udder were classified as "many" or "few," "prominent" or "not prominent." The distance from the fore udder to the well on each main vein was taken with a tape drawn tight from the point where the vein leaves the udder. Its length was obtained by following its course with a small wooden wheel six inches in circumference and graduated to half inches. Its contour was described as "straight," "nearly straight," "slightly crooked," "fairly crooked" or "very crooked," being considered "straight" if there was not more than a half inch difference between the distance from the udder to well as measured by the tape and the length as determined by the use of the wheel and being considered "very crooked" if it doubled back on itself considerably. The diameter of the vein was taken with calipers to one-sixteenth of an inch at a point a few inches back of the well where it is usually straight and can be satisfactorily and accurately measured. The size was described as "flat," "nearly flat," "prominent," "fairly prominent" or "very prominent," being considered "flat" if its protuberance was slight as compared with its diameter. In "very prominent" veins the diameter and size (protuberance) were about equal. The diameter of the well was taken to thirty-seconds of an inch. Since it would be exceedingly laborious to caliper each well separately, and since it seemed desirable in the correlation tables to grade the sizes of wells by even steps, and since the areas of circles are to each other as the squares of their diameters, a system was devised whereby the wells were graded into seven sizes. Taking $^{28}/_{32}$ inch or $^{7}/_{8}$ inch as the largest diameter found in the station herd, the figure 7 was squared. Seven numbers were chosen such that they would grade evenly from 0 to 49, as in the second column of the table on "well sizes." Taking the square root of each of these parts and reducing again to thirty-seconds of an inch, the diameters of the various sizes of wells to be compared were obtained.

TABLE OF WELL SIZES

Well number	Diameter squared	Diameter as eighths of an inch	Equivalent diameter in thirty-seconds of an inch
1	7	2.65	10.6
2	14	3.74	14.96
3	21	4.58	18.32
4	28	5.29	21.16
5	35	5.92	23.68
6	42	6.48	25.92
7	49	7.	28.

In practice the size of the well was always judged with the middle finger of the right hand. The depth and shape were also thus judged. Considerable practice was required to enable one to use this system,

but in time each writer was able thus quickly and accurately to judge the size of the wells. Thus, for example, No. 7 leaves considerable space around the point of the finger, whereas No. 3 is an even fit. The shape of the well was described as "circular," "oblong" and the depth as "deep," "medium" or "shallow."

Measurements on a few cows were taken several times during the year to find out how much variation there is in the same vein at different stages of the lactation period. A slight increase was found in the size and crookedness of the veins of some young cows after freshening but not enough appreciably to affect the outcome. The age of the cow was not taken into consideration in making up the tables since it would require several years of consecutive study to determine the effect of age upon the milk-vein system. It is probable that in a large population of all ages, such as was used in the present study, the results would be practically the same as would have been secured had corrections been applied for the different ages, even if the data were at hand enabling one to make such corrections.

The most common variations found to exist in the milk-vein systems of the cows under survey were those known as "abdominal extensions," "forks" and "branches." No others were found in sufficient numbers to warrant their use.

An "abdominal extension" is a vein, usually smaller than the main vein and extending from the main well forward and passing to another and usually smaller well into the chest sometimes nearly or quite as far forward as the armpit.

A "fork" is a vein proceeding from the udder as two veins and then merging into one.

A "branch" is a vein originating in and again merging into a main vein; or proceeding from and not again joining the main vein.

The following comparisons were made:

1. The relation of the size of the milk-wells to milk production: 335 cows (Aldrich), 541 cows (Dana).

2. The relation of the size of the milk-wells to fat production: 539 cows (Dana).

3. The relation of the diameter of the milk-veins to milk production: 335 cows (Aldrich), 545 cows (Dana).[1]

4. The relation of the length of the milk-veins to milk production: 103 cows (Aldrich), 235 cows (Dana).

[1] The relation of the diameter of the milk-veins to fat production was also studied by one of us (J. W. D.); but owing to the existence of errors in the data gathered of such a nature that they cannot be corrected the calculations are not included.

5. The relation of the length of the milk-veins to fat production: 241 cows (Dana).

6. The relation of the existence of forked veins to milk production: 98 cows (Aldrich), 111 cows (Dana).

7. The relation of the existence of forked veins to fat production: 132 cows (Dana).

8. The relation of extensions, or of forks and extensions, to milk production: 87 cows (Aldrich), 133 cows (Dana).

9. The relation of extensions, or of forks and extensions, to fat production: 144 cows (Dana).

10. The relation of the length of the cow to the length of the milk-veins: 612 cows (Dana).

It may not be amiss to remark at this point that the careful measurements of these 600 and more cows, the assembling of the data, its arrangement in the several categories and the final calculations, were a laborious task. The writers are indebted to the station computer, Mr. W. J. Lamplough, for careful checking of all computations.

The correlations were worked out in accordance with the theory of probabilities as set forth in Davenport's "Principles of Breeding," chapter xiii and appendix, sections vii, viii (pp. 453-472; 698-708).

It may be well at this point, since this bulletin may be read by some whose ideas concerning correlation are not clearly defined, to indicate just what is meant by this term and how the system was operated in the present case.

It is well understood that certain characteristics tend to be interdependent, to rise or fall together, to be actuated by a common cause, whereas other characteristics vary in a quite unrelated fashion. Thus, length and weight of corn ears, or the size and strength of horses are closely related the one to the other, whereas the length and edibleness of corn ears, or the color and strength of horses are not in any respect determined the one by the other. There is close correlation in the one instance, little or none in the other. Two sorts of correlation are recognized; perfect correlation, represented by a ratio of +1, wherein one character is always correspondingly and proportionately paralleled by another and related character; perfect negative corellation, represented by a ratio of —1, wherein one character is always correspondingly and proportionally divergent as compared with another and related character; and, of course, that condition of affairs is recognized, represented by zero, wherein characters are entirely unrelated to each other, evincing no evidences of causative relations. Of course all gradations are found in practice between +1 and —1, on

the one side or the other of zero. Neither perfect nor perfect negative correlations are likely to occur. In proportion, however, as the ultimate result, usually expressed as a "correlation coefficient," departs from the zero point and approaches the +1 or the —1 points, correlation on the one hand or anti-correlation on the other is indicated. An approximation to zero betrays lack of relationship, neither indicative of a common cause nor of mutual exclusion.

It should be remembered, however, that the problem is rarely a simple one, especially as applied to living beings. Mixed causes are at work. "For example," says Davenport, "many, if not most, good cows have a capacious 'barrel' and a roomy udder, and men have been led to assume a perfect correlation between these special characters and milk production; whereas the truth is that the correlation, though high, is something less than unity, because good cows are known with small barrels and with inconspicuous udders. * * * The average man asks whether or not two characters are correlated, and expects a positive answer, Yes or No; whereas the question should be, to what extent do two characters appear together? expecting for an answer a fraction lying somewhere between zero and unity, say perhaps 40 to 60 percent, as in correlation of length to weight of corn ear."

A "correlation coefficient" is a statistical constant which indicates to what extent one character can be predicted by another. Thus, in the table on page 15, if the ultimate result, the correlation coefficient (r, which in this case was 0.262), equalled +1, an increase in size of the milk-well might be expected always to be accompanied by a proportionate increase in milk production; this would be the natural inference to be drawn under such circumstances. If, on the contrary, the coefficient were —1, the reasoning would be that in proportion as the milk-wells increased in size, a relative decrease in milk production would ensue. And if the coefficient were zero, the probable milk production could be in no degree whatever predicted from the size of the milk-wells; and in proportion as the correlation coefficient approaches zero in its value the likelihood of the existence of causal interrelations is lessened.

The "regression coefficients" represent fixed ratios between deviations of correlated characters; that is to say, if it is known just how much one of the characters differs from the mean in either unit of measurement—let us say in the case now in hand, the annual milk yield stated as pounds—one would be enabled to predict with a fair degree of certainty to what extent the associated character—in the present case the size of the milk-wells—would be likely to differ from its mean

in its unit of measurement, that is to say, in fractions of an inch. Thus in the case now in hand, table I, referring to the regression coefficients, one of which indicates probabilities as regards milk-flow, the other as regards size of the milk-wells, it may be assumed that there is almost no relationship whatever betrayed by the regression coefficient in the one case of the size of the wells, since 0.003 inch is a quantity so small as to be quite beyond accurate measurement, whereas perhaps something may be predicted as to the amount of increase or decrease in the milk-flow which may be expected following increases or decreases in the milk-well size; although the figure is not large enough to be deemed decisive.

It hardly seems necessary to print the entire ten tables in full. Table I, which sets forth in detail the calculations made in connection with the relation of size of milk-wells to the milk-flow, seems sufficient to the purpose. The other correlation data on which the results are based are also included in tables II to IX for the purposes of any who may care further to pursue this matter.

The following notation was used. In order to make clear the relationships, the processes and results as developed in table I are set forth in parentheses after the notation definitions.

MILK PRODUCTION—POUNDS

f_w Class frequencies of total population with respect to weight of milk (14 — — —4 = 541)

G_w Guess at class mark nearest to mean weight of yearly milk production in pounds (5,000)

D_w Deviation of weight from guess at mean (—2,500 to 4,500)

C_w Correction to guess at mean ($f_w D_w \div 541 = -19.409$)

M_w Mean weight of yearly milk production ($G_w - C_w = 4{,}980.591$ pounds*)

σ_w Standard of deviation in weight ($[\sqrt{f_w (D_w)^2 \div 541}] - (C_w)^2 = 1{,}333.866$*)

MILK-WELLS—SIZE

f_s Class frequencies of total population with respect to size of milk-wells (76 — — — 5 = 541)

G_s Guess at class mark nearest to mean size of wells (28)

D_s Deviation in size from guess at mean (—14 to 49)

C_s Correction to guess at mean ($f_s D_s \div 541 = +3.209$)

M_s Mean size of milk-wells ($G_s + C_s = 31.209$*)

σ_s Standard of deviation in size ($[\sqrt{f_s (D_s)^2 \div 541}] - (C_s)^2 = 13.561$*)

$r =$ Correlation coefficient $\left(\frac{\Sigma D_w D_s}{N} - C_w C_s\right) \frac{1}{\sigma_w \sigma_s}$

$\frac{\Sigma D_w D_s}{N} - C_w C_s \left(\frac{2{,}530{,}500}{541} - 62.283 = 4{,}739{,}732\right)$

$r = \frac{4{,}739{,}732}{(1{,}333{,}866)\ (13{,}561)} = 0.262$*

$r\frac{\sigma_w}{\sigma_s}$ = regression coefficient relative to weight of milk

$\left(0.262\ \frac{1{,}333{,}866}{13{,}561} = 25.770^*\right)$

$r\frac{\sigma_s}{\sigma_w}$ = regression coefficient relative to size of milk-well

$\left(0.262\ \frac{13{,}561}{1{,}333{,}866} = 0.003^*\right)$

*In these cases, as indicated in the table, the result is correct within a probable error as stated, calculated according to the recognized formulas for such determinations as given in Davenport, "Principles of Breeding," p. 703.

TABLE I. SIZE OF WELLS—MILK-FLOW

Size $G_s = 28$

$G_w = 5000$	14	21	28	35	42	49	56	63	70	77	f_w	D_w	f_wD_w	$(D_w)^2$	$f_w(D_w)^2$	ΣD_wD_s
2500	7	2	3	1	1	..	..	..	..	..	14	—2500	—35000	6250000	87500000	22750(
3000	1	8	13	4	1	..	..	..	..	..	27	—2000	—54000	4000000	108000000	5600(
3500	2	10	16	16	4	..	..	..	..	..	48	—1500	—72000	2250000	108000000	—10500(
4000	15	17	14	16	7	2	..	..	1	1	73	—1000	—73000	1000000	73000000	— 1400(
4500	16	23	17	21	9	3	2	1	1	2	95	— 500	—47500	250000	23750000	— 9100(
5000	19	16	20	14	11	8	2	2	1	1.	94	0		0		(
5500	7	15	12	13	4	4	3	1	3	..	62	500	31000	250000	15500000	13650(
6000	1	12	4	4	7	3	2	1	2	..	36	1000	36000	1000000	36000000	26600(
6500	6	8	5	7	4	3	..	1	..	1	35	1500	52500	2250000	78750000	16800(
7000	2	4	1	3	3	1	3	1	1	..	19	2000	38000	4000000	76000000	37800(
7500	..	3	4	5	2	2	3	2	..	..	21	2500	52500	6250000	131250000	59500(
8000	..	1	1	2	2	..	..	..	1	..	7	3000	21000	9000000	63000000	23100(
8500	..	..	1	..	1	..	1	..	1	..	4	3500	14000	12250000	49000000	29400(
9000	..	..	..	..	..	2	..	..	..	..	2	4000	8000	16000000	32000000	16800(
9500	..	..	1	..	2	1	..	..	..	..	4	4500	18000	20250000	81000000	22050(

f_s	D_s	f_sD_s	$(D_s)^2$	$f_s(D_s)^2$
76	—14	—1064	196	14896
119	— 7	— 833	49	5831
112	0			
106	7	742	49	5194
58	14	812	196	11368
29	21	609	441	12789
16	28	448	784	12544
9	35	315	1225	11025
11	42	462	1764	19404
5	49	245	2401	12005
541		541)1736		541)105056
		$C_s = 3.209$		194.188
				$-(C_s)^2$ 10.298
				183.890

541)—10500

$C_w = -19.409$

	)962750000	)2530500
	1779574.861	4,677.449
$-(C_w)^2$	—376.709	+62.283
	1779198.152	4,739.732

$\sigma_w = 1,333.866 \pm 27.344$

$\sigma_s = 13.561 \pm 0.278$

$M_w = 4980.591 \pm 38.682$

$M_s = 31.209 \pm 0.393$

$$r = \frac{4,739.732}{(1333.866)\ (13.561)} = 0.262 \pm 0.0$$

$$r\frac{\sigma_w}{\sigma_s} = 25.770 \pm 2.753$$

$$r\frac{\sigma_s}{\sigma_w} = 0.003 \pm 0.0003$$

$*(C_wC_s)$

Table II. Size of Wells—Milk-Flow

Size $G_s = 28$

Weight G_w = 5500	14	21	28	35	42	49	56	63	70	77	84	91	98	f_w
2500	1	..	1	..	..	..	..	..	..	..	..	..	..	2
3000	..	2	2	..	..	..	..	..	..	..	..	..	..	4
3500	1	5	..	..	..	..	..	..	..	..	..	..	..	6
4000	6	14	10	8	1	..	..	..	1	..	..	..	1	41
4500	8	19	7	5	4	1	..	1	..	..	..	..	1	46
5000	15	13	11	13	2	3	1	1	1	1	..	..	..	61
5500	18	11	14	9	2	3	..	1	2	..	..	..	..	60
6000	6	9	11	10	4	2	2	1	1	..	..	..	..	46
6500	1	5	4	2	2	3	..	1	..	..	..	..	..	18
7000	6	4	5	6	2	1	2	..	1	..	..	..	..	27
7500	2	3	..	..	..	..	2	..	..	..	..	..	..	7
8000	..	1	4	4	1	..	..	..	..	..	..	..	..	10
8500	..	..	1	..	1	..	..	..	..	..	..	..	..	2
9000	..	..	1	..	..	1	..	..	..	..	..	..	..	2
9500	..	..	..	..	1	..	..	..	..	..	..	..	..	1
10000	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10500	..	..	1	..	..	1	..	..	..	..	..	..	..	2
f_s	64	86	72	57	20	15	7	5	6	1	..	..	2	335

Correlation coefficient 0.151 ± 0.031.

Table III. Size of Wells—Fat Content

Size $G_s = 35$

G_w = 225	14	21	28	35	42	49	56	63	70	77	f_w
100	2	2	..	1	2	1	..	..	..	..	8
125	4	5	7	5	3	..	2	1	1	..	28
150	3	10	9	10	9	2	3	2	1	..	49
175	..	5	16	18	10	2	2	2	..	2	57
200	2	4	14	19	10	5	1	3	3	4	65
225	2	2	17	17	18	7	11	4	1	5	84
250	..	7	11	12	16	17	7	2	2	3	77
275	1	6	11	12	6	10	9	5	3	2	65
300	1	5	6	10	9	9	4	2	3	3	52
325	..	1	1	4	4	2	4	1	1	1	19
350	..	..	2	4	3	3	..	1	2	2	17
375	..	..	..	4	2	1	1	1	1	..	10
400	..	..	1	..	..	..	..	..	1	3	5
425	..	..	1	..	1	..	..	..	1	..	3
f_s	15	47	96	116	93	59	44	24	20	25	539

Correlation coefficient 0.284 ± 0.027.

TABLE IV. DIAMETER OF MILK-VEINS—MILK-FLOW

Diameter G_d = 126

Weight G_w = 5500	14	42	70	98	126	154	182	210	238	266	294	322	350	378	406	434	462	490	518	546	574	602	630	658	686	714	742	f_w
2500	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
3000	..	1	1	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
3500	..	..	1	3	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6
4000	..	..	10	21	7	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	41
4500	..	1	7	22	7	5	..	..	1	..	..	1	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	46
5000	..	1	8	20	23	3	1	..	..	..	..	..	1	..	1	2	..	..	..	1	..	..	..	..	..	..	..	61
5500	..	1	9	21	15	7	3	..	1	..	..	1	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	60
6000	..	..	4	18	15	4	2	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..	46
6500	..	..	2	4	9	1	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18
7000	..	..	3	8	10	1	1	..	..	..	..	1	..	..	..	1	..	..	..	..	1	1	..	..	..	..	..	27
7500	..	..	..	2	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7
8000	..	..	..	2	5	2	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10
8500	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
9000	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
9500	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
10000	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
10500	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2
	..	4	47	122	100	27	8	4	2	..	2	3	4	..	2	3	..	..	..	1	2	2	..	..	..	1	1	335

Correlation coefficient 0.198 ± 0.036.

TABLE V. DIAMETER OF MILK-VEINS—MILK-FLOW

Diameter G_d = 98

Weight G_w = 5000	14	42	70	98	126	154	182	210	238	266	294	322	350	378	406	434	462	490	518	546	574	602	630	658	686	714	742	f_w
2500	..	6	6	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16
3000	..	8	5	5	5	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	24
3500	..	5	8	11	1	1	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28
4000	..	6	7	33	12	4	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	64
4500	..	3	21	33	12	5	1	..	1	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	78
5000	..	8	17	29	24	16	2	..	..	..	..	..	..	1	1	2	..	..	..	1	..	..	..	..	..	..	..	101
5500	..	3	11	29	19	7	3	..	1	..	..	..	1	..	1	..	..	..	..	..	1	..	..	..	..	..	..	76
6000	..	1	7	20	16	5	3	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	55
6500	..	..	3	6	13	1	1	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	26
7000	..	1	4	12	11	2	2	..	..	..	..	..	1	..	..	1	..	..	..	..	1	1	..	..	..	..	..	36
7500	..	..	2	4	7	2	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16
8000	..	..	..	2	5	3	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13
8500	..	..	..	..	2	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
9000	..	..	..	..	2	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
9500	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
10000	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10500	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	3
f_d	..	42	91	186	131	48	17	5	3	..	..	2	3	4	2	3	..	..	..	1	2	2	..	..	..	2	1	545

Correlation coefficient 0.282 ± 0.027.

TABLE VI. LENGTH OF MILK-VEINS—MILK-FLOW

Length G_l = 18

Weight G_w	11	12	13	14	15	16	17	18	19	20	21	22	23	24	f_w
2500	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1
3000	..	..	..	..	1	1	..	..	..	..	..	..	..	..	2
3500	..	..	..	..	1	1	..	..	1	..	..	..	..	..	3
4000	1	..	2	..	..	2	1	4	..	2	2	..	1	1	16
4500	..	..	..	2	1	2	2	2	5	1	1	2	..	..	18
5000	..	..	..	..	2	3	2	4	2	2	..	1	..	..	16
5500	..	..	..	2	..	1	3	2	2	2	2	1	..	..	15
6000	..	..	..	..	1	3	4	3	2	1	3	..	1	..	18
6500	1	..	1	..	..	..	..	1	..	..	..	..	1	..	4
7000	..	..	..	..	1	2	1	1	..	..	1	..	..	..	6
7500	..	..	1	..	..	..	..	..	1	..	..	..	..	..	2
8000	..	..	..	..	..	..	1	..	..	1	..	..	..	..	2
	2	..	4	4	7	15	14	18	13	9	9	4	3	1	103

Correlation coefficient 0.003 ± 0.066.

TABLE VII. LENGTH OF MILK-VEINS—MILK-FLOW

Length G_l = 16

Weight G_w = 5000	11	12	13	14	15	16	17	18	19	20	21	22	23	24	f_w
2500	..	..	3	3	3	2	..	1	..	..	..	..	..	..	12
3000	..	2	1	3	4	3	3	..	1	..	..	..	..	..	17
3500	..	..	1	3	4	2	4	1	2	..	..	..	..	..	17
4000	2	..	4	2	3	12	6	7	2	2	2	..	1	1	44
4500	1	..	..	3	9	3	5	3	5	1	1	2	..	..	33
5000	..	1	2	2	3	5	7	6	3	..	..	1	..	..	30
5500	..	..	1	4	4	5	3	3	2	2	2	1	..	..	27
6000	..	..	1	..	1	5	5	3	2	2	3	1	1	..	24
6500	1	..	1	..	1	..	..	3	..	1	..	..	1	..	8
7000	..	..	..	1	1	2	2	1	..	..	1	..	..	..	8
7500	..	..	1	1	1	1	..	1	1	..	..	..	..	..	6
8000	..	..	1	..	2	..	3	..	..	3	..	..	..	..	9
f_l	4	3	16	22	36	40	38	29	18	11	9	5	3	1	235

Correlation coefficient 0.211 ± 0.042.

TABLE VIII. LENGTH OF MILK-VEINS—FAT CONTENT

Size G_d = 16

G_w = 225	11	12	13	14	15	16	17	18	19	20	21	22	23	24	f_w
100	..	..	1	3	..	2	..	1	..	..	..	..	..	..	7
125	..	1	1	1	1	2	4	..	1	..	..	..	..	..	11
150	1	..	1	4	7	5	4	1	2	2	1	..	1	..	29
175	1	1	4	4	6	3	7	4	2	1	..	..	..	..	33
200	3	..	2	2	4	6	8	2	1	..	..	..	..	..	28
225	..	1	..	9	7	9	8	2	2	2	..	..	1	..	41
250	..	..	2	5	6	6	5	..	1	..	1	..	..	..	26
275	..	..	3	2	4	5	3	5	1	..	..	..	..	..	23
300	..	1	..	2	4	12	1	3	..	2	..	..	..	..	25
325	..	..	..	..	..	3	2	..	..	..	..	..	1	..	6
350	..	..	..	1	..	1	2	..	..	..	..	1	..	..	5
375	..	1	1	1	1	..	..	..	..	1	..	..	..	..	5
400	..	..	..	..	..	1	..	..	..	..	..	..	1	..	2
f_l	5	5	15	34	40	55	44	18	10	8	2	1	4	..	241

Correlation coefficient 0.096 ± 0.043.

TABLE IX. LENGTH OF THE COW'S BODY—MILK-VEIN LENGTHS

Length $G_v = 82$

Length $G_c = 57$	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	f_c
52	1	2	..	..	2	1	2	2	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	11
53	..	..	1	..	4	3	3	2	1	3	1	..	1	1	1	..	..	..	..	..	..	..	..	21
54	1	2	..	1	3	3	5	3	6	7	3	5	3	3	1	..	..	..	..	..	..	..	..	46
55	2	..	..	..	3	8	8	7	7	7	8	9	5	7	5	2	1	1	..	..	1	..	..	81
56	..	..	1	2	3	4	4	7	13	4	12	8	7	5	9	1	1	2	..	..	..	..	..	83
57	1	..	1	4	3	4	5	2	12	12	12	3	9	4	11	7	5	1	1	3	..	..	..	100
58	1	..	1	1	3	5	7	5	4	8	9	13	10	2	9	4	2	4	1	3	..	..	..	92
59	..	..	..	..	3	3	2	1	5	7	3	7	8	7	8	3	3	3	2	1	..	..	..	66
60	..	1	1	..	..	1	1	2	2	4	5	7	5	3	5	3	3	2	1	3	..	..	4	53
61	..	..	..	..	..	..	..	..	2	2	5	5	4	1	4	5	2	2	1	2	..	..	..	35
62	..	..	..	..	..	1	..	2	2	..	1	1	..	2	..	2	..	1	..	1	..	..	1	14
63	..	..	..	..	..	1	..	..	2	1	..	..	..	1	..	2	..	1	..	1	1	..	..	10
f_v	6	5	5	8	24	34	37	33	56	55	59	59	52	36	53	29	17	17	6	14	2	..	5	612

Correlation factor 0.376 ± 0.023.

The essential outcome of all these calculations are the correlation coefficients (r) and the regression coefficients. $\left(r\frac{\sigma_w}{\sigma_s};\ r\frac{\sigma_s}{\sigma_w}\right)$ These were obtained by one of us (A. W. A.) in 1913, using from 98 to 335 cows and by the other (J. W. D.) in 1914 using the data secured by his predecessor and in addition data secured from almost as many more cows. Each writer separately worked up his material and it is all summarized in the following tabular statements which show the several coefficients together with the statement of the probable errors, calculated according to the formulas given by Davenport, page 703.

THE RELATION TO MILK AND FAT PRODUCTION OF THE MILK-VEIN SYSTEM

	Number of cows	Calculations by[1]	Correlation coefficients	Regression coefficients with respect to milk-flow	Regression coefficients with respect to milk-vein system
1. Size of wells: milk	335	A	0.151 ± 0.031	13.441 ± 3.242	0.002 ± 0.0
	541	D	0.262 ± 0.027	25.770 ± 2.753	0.003 ± 0.0003
2. Size of wells: fat	539	D	0.284 ± 0.027	1.217 ± 0.120	0.066 ± 0.0065
3. Diameter of veins: milk	335	A	0.193 ± 0.036	2.544 ± 0.475	0.015 ± 0.003
	545	D	0.282 ± 0.027	4.618 ± 0.459	0.017 ± 0.002
4. Length of veins: milk	103	A	0.003 ± 0.066	—1.2597 ± 27.881	—0.00007 ± 0.0001
	235	D	0.211 ± 0.042	114.512 ± 23.337	0.0004 ± 0.0000
5. Length of veins: fat	241	D	0.096 ± 0.043	2.865 ± 1.283	0.003 ± 0.001

THE RELATION OF THE LENGTH OF THE COW'S BODY TO THE LENGTH OF THE MILK-VEIN SYSTEM

	Number of cows	Calculations by[1]	Correlation coefficients	Regression coefficients in respect to length of cow	Regression coefficients in respect to length of veins
10.	612	D	0.376 ± 0.023	0.653 ± 0.043	0.216 ± 0.01

THE RELATION TO MILK AND FAT PRODUCTION OF FORKS AND EXTENSIONS OF THE MILK VEIN SYSTEM

	Number of cows	Calculations by[1]	Mean milk or fat yields		Number of cows	Mean milk or fat yields	Increase: forks or extension over simple systems
6. Simple systems	103	A	5180 lbs. ± 73 lbs.	Forked veins	98	5362 lbs.	182 lbs.
6. Simple systems	235	D	4819 lbs. ± 59 lbs.	Forked veins	111	5437 lbs.	618 lbs.
7. Simple systems	241	D	223 lbs. ± 3 lbs.	Forked veins	132	236 lbs.	13 lbs.
8. Simple systems	103	A	5180 lbs. ± 73 lbs.	Extension, etc.	87	5626 lbs.	446 lbs.
8. Simple systems	235	D	4819 lbs. ± 59 lbs.	Extension, etc.	133	5387 lbs.	568 lbs.
9. Simple systems	241	D	223 lbs. ± 3 lbs.	Extension, etc.	144	243 lbs.	20 lbs.

[1] A, Aldrich; D, Dana.

It should be remembered, before attempting to study these data, that correlation coefficients always lie between the figures +1 and —1; that if the figure is +1 or approaches +1 the two characters are causally related; that if it is —1 or approaches —1, they are mutually exclusive; and that if the figure is zero or relatively near zero, two characters are indifferent to each other, and not causally related. Thus, for instance, in the example cited by Davenport as to the correlation of the weight of the ears of corn relative to their length, the correlation factor in a study of 993 ears is 0.87. It approaches unity. It is well understood that long ears tend to weigh more than short ears.

A cursory survey of this table indicates at once that the correlation coefficients approach zero much more nearly than they approach unity and that the probable error is in all cases relatively so small as to cut no figure. Yet on the other hand they do hug the zero mark, save in one instance. These data would seem to justify the following conclusions:

1. In this study, involving the careful comparison of the milk-vein systems of from about 250 to about 550 cows whose yearly milk and fat yields were in hand, some degree of correlation seems to be traceable as between—

(a) The size of the milk-wells and the milk or fat yields (0.151 ± 0.031; 0.262 ± 0.027; 0.284 ± 0.027).

(b) The diameter of the milk-veins and the milk yields (0.193 ± 0.036; 0.282 ± 0.027).

The results seem indeterminate in respect to:

(c) The length of the milk-veins and the milk or fat yields (0.003 ± 0.066; 0.211 ± 0.042; 0.096 ± 0.043).

In but a single case—the relation of the length of the milk-veins to the milk yield—did the regression coefficients show anything of importance.

2. The result as to the relation of the body length to milk-vein length secured with more than 600 cows, seems quite indicative. The correlation coefficient (0.376 ± 0.023) betrays a considerable degree of interrelationship.

3. The data shown in the lower part of the table seem to be even more positive in character. The number of animals under survey was smaller and the results were secured in quite a different way. The same system of calculation was employed as in connection with the other comparisons, save that correlation coefficients were not determined for cows upon whose abdominal walls appeared the forked veins or the extensions. The calculations extended only so far as to

enable one to determine their mean milk or fat yields, and these were compared with the mean milk or fat yields of the cows whose bodies were not thus bedizened. These comparisons, stated in the column headed "gains" as pounds, are not, of course, absolute, for the reason that the mean milk or fat yields in the case of cows whose milk-vein systems were neither forked nor extended are qualified by a plus or minus error. A similar error doubtless exists for the fork or extension bedecked cows, but its extent could not be determined because it was impossible to measure the lengths or sizes of these forks, etc.; only their presence could be indicated; and without a numerical statement of the second item in the comparison no correlation coefficients can be determined. Consequently the gains as stated for the cows with forks and extensions are subject to a correction factor, either plus or minus in its nature and of an unknown value. The most that can be said, therefore, in view of the fact that the trend is always in the plus direction, is that there seems to be some probability that cows showing forks or extensions may on that account be somewhat better milk and butter producers than those not thus favored.

The following points are of interest in this connection, for the reason that they seem significant:

Of the 193 cows showing no forks, six made less than 4,000 pounds of milk and four more than 7,000; of the 98 showing forks, six made less than 4,000 pounds and eight more than 7,000.

Of the 193 cows showing no extensions, six made less than 4,000 pounds of milk and four more than 7,000; of the 87 showing extensions, none made less than 4,000 and ten more than 7,000.

Davenport well says in the summary of his chapter XIII that "correlation is generally a relative matter and impressions are exceedingly deceptive. Nothing but actual calculation will show the extent to which characters really move together." Certainly it was a fair question to raise, whether the score cards, in so far as they relate to the milk-vein system, had not been constructed on the basis of impression rather than of accurate study. It is hoped that these "actual calculations will show (or at least throw some light upon) the extent to which characters (milk-vein systems and milk-flow in this case) really move together," that is to say are correlated or interrelated.

THE COST OF MILK AND FAT PRODUCTION IN VERMONT IN 1911 AND 1912

BY G. M. NELSON

The following study sets forth the essential results of a review of the cost of producing milk and butterfat on Vermont farms under the conditions obtaining in the years 1911 and 1912. A survey was made of the records of 71 herds located in Addison, Caledonia, Chittenden, Franklin, Orleans, Orange and Rutland counties and owned by members of cow test associations. The data were secured from association records and by consultation with her owners. The records of 1,547 cows contributed to this study, and, in certain portions, of 2,319 cows.

THE OUTGO

Ten distinct factors determine the cost of keeping a cow, namely: feed, labor, shelter, equipment, bedding, bull, interest, depreciation, taxes and insurance. The data concerning feed costs were secured directly from the association records; that for the remaining items by means of personal interviews.

The following table exhibits in concise form the essential statements for these ten items, expressed as maxima, minima and averages. The distribution of these expense items is further and clearly shown upon the left hand circle on page 37.

THE COST OF KEEPING A COW FOR A YEAR—(CHARGES OTHER THAN FEED)

(71 herds; 1547 cows; herds varying from 4 to 80 cows, averaging 21.8 cows)

	Maximum	Minimum	Average
Labor, per cow	$30.42	$10.95	$18.82
Shelter, per cow	19.59	0.83	4.93
Equipment, per cow	4.00	0.06	1.06
Bedding, per cow	4.67	0.30	1.37
Bull, per cow	9.50	0.75	2.18
Interest, per cow	8.10	2.10	3.23
Depreciation, per cow	13.50	1.50	4.49
Taxes, per cow	....	....	0.52
Insurance on barn and cow	....	....	0.27
	$53.39	$19.18	$36.87

THE COST OF KEEPING A COW FOR A YEAR

(The records of the feed costs for 1170 cows, whose owners were visited and interviewed, used for maximums and minimums; those of 2319 cows for averages)

	Maximum	Minimum	Average
Roughages	$31.72	$17.90	$25.93
Concentrates	36.84	3.67	16.25
Totals	$65.34	$21.35	$42.18
Total average cost exclusive of feed			$36.87*
Total average cost for feed			42.18*
Total cost per year, per cow			$79.05*

*Compare with the data from 58 herds on page 31. The figures are not materially unlike.

It should be said concerning these various items:

Labor. Includes the estimate of the number of hours spent daily throughout the year in feeding, watering, milking, cleansing stables, grooming and similar work, but does not include the time employed in the care of calves, young stock, etc.; rated at 15 cents an hour.

Shelter. Includes interest, depreciation and taxes on the barn where the cows were kept and the same items on half the total cost of the shelter covering the hay and other crops.

Equipment. Includes insurance, depreciation and taxes on separators, engines, motors, pails, brushes, shovels, hoes and other minor utensils commonly used in the dairy. The value of the equipment and the rate of their depreciation were determined by their owners, 6 per-cent interest charges being added arbitrarily.

Bedding. Sawdust, shavings and straw; more commonly sawdust, where the cost of cartage is not too great, straw being used mainly for the bedding of horses, calves, and hogs.

Bull. Includes feed, labor and interest, etc., charges.

Interest. Six percent on valuations of the cows.

Depreciation. Covers the estimate of the losses due to death, disease, accidental injuries, increase in age; or, in other words, the amount in money required to maintain the number of the herd from year to year. The owners' estimates were found to vary widely, and in four cases no data whatever could be secured.

Taxes. Based on the grand list value of the cows and the local tax rates, which averaged $1.65.

Insurance. Difficult to determine, since as a rule all buildings, stock and tools were insured as a unit. As near as could be estimated, the average for 168 cows was 27 cents, covering the insurance of the animal and her share of the insurance on the barn.

THE RELATION OF THE SIZE OF A HERD TO MAINTENANCE CHARGES OTHER THAN FOOD

Number of cows in herd	Number herds in class	Labor	Shelter	Equipment	Bedding	Herd Bull	Average total charge
4 -8	4	$23.61	$8.20	$2.80	$2.30	$4.20	$47.54
9-13	11	23.40	7.30	1.60	1.80	3.90	41.80
14-18	14	21.80	4.30	1.10	1.00	2.60	38.90
19-23	18	19.23	4.30	1.10	1.30	2.30	35.83
24-28	11	18.10	3.10	1.30	2.00	1.90	35.10
29-33	5	17.70	3.70	0.80	1.30	1.70	35.00
34-38	3	13.30	2.50	0.60	0.60	1.30	24.60
39-44	3	20.70	3.70	1.20	1.20	1.80	41.50
	69						
55	1	19.90	4.10	0.40	2.27	1.82	43.17
80	1	20.50	19.59	0.30	0.56	0.95	48.52
Average		$18.82	$4.93	$1.06	$1.37	$2.18	$36.87
Graph reference		I	II	III	IV	V	VI

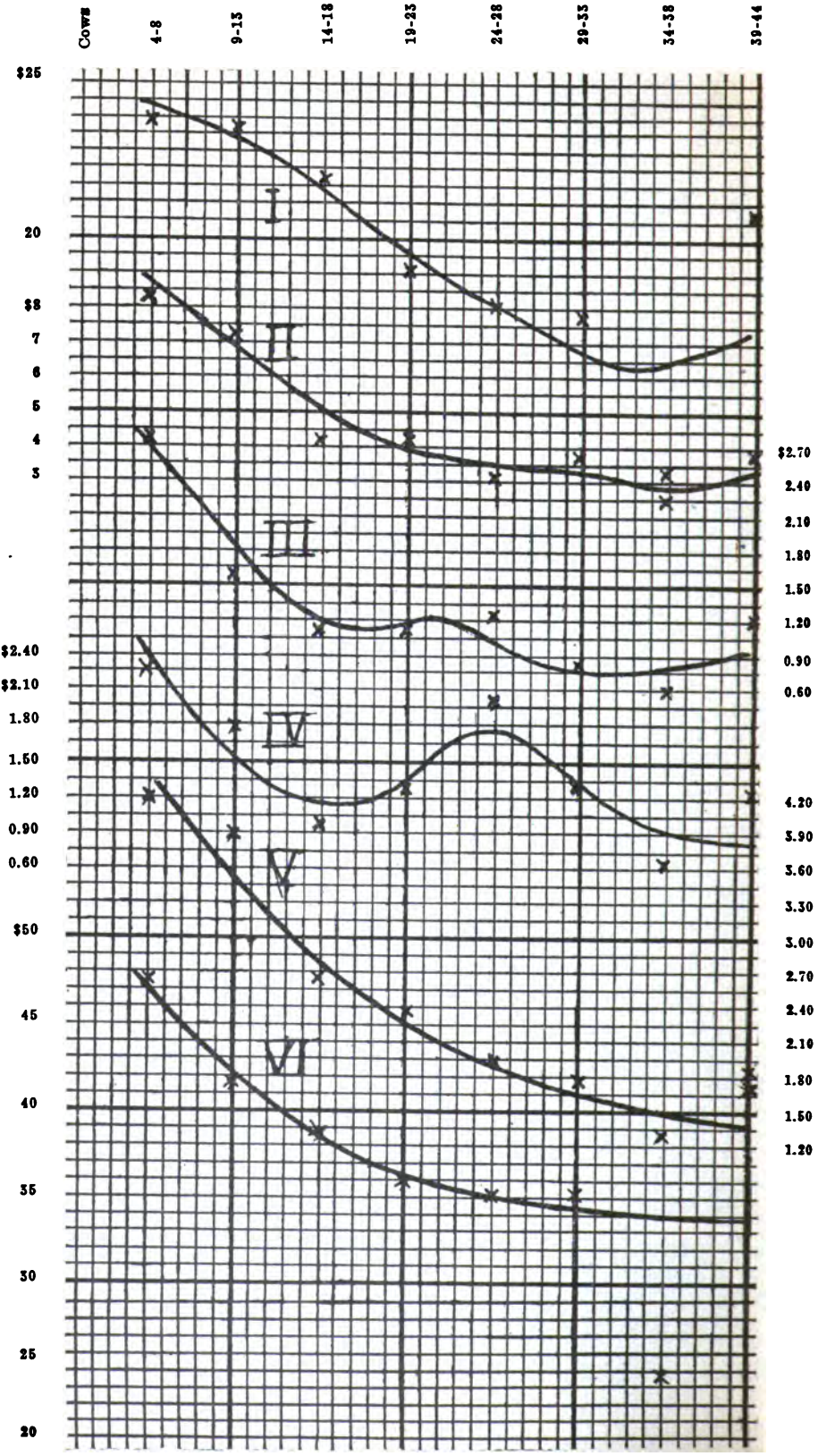
The following graphs set forth some of these points:

1. The cost of labor per cow in herds of different sizes.
2. The cost of shelter per cow in herds of different sizes.
3. The cost of equipment per cow in herds of different sizes.
4. The cost of the bedding in herds of different sizes.
5. The cost of the keeping of the bull in herds of different sizes.
6. The total cost of keeping a cow, exclusive of the food, in herds of different sizes.

Referring now to the above table and to these graphs, it may be said:

Labor (Graph I). The estimated cost of labor was proportionately greater in small herds than in herds of 20 or more cows, being highest in very small herds and decreasing steadily until the herd numbered about 35. It was relatively high in the larger herds, where perhaps more pains were taken or a larger proportion of the work was done with hired help.

Shelter (Graph II). The average cost of shelter was practically $5 per cow. The interest and depreciation (10 percent annually) amount to 93 percent and taxes to 7 percent of this sum. In one case only 83 cents a cow was charged, the animals being kept in an old and poorly constructed barn. The 80-cow herd was housed in an expensive barn designed for a fancy stock farm, and the shelter charge, $19.59 per cow, was excessive. In general, the average cost of shelter per cow decreased until a limit of 35 cows was reached, beyond which the tendency was slightly to increase this charge, apparently because of the


Cows
4-8
9-13
14-18
19-23
24-28
29-33
34-38
39-44
$25
20
$8
7
6
5
4
3
$2.40
$2.10
1.80
1.50
1.20
0.90
0.60
$50
45
40
35
30
25
20
I
II
III
IV
V
VI
$2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
4.20
3.90
3.60
3.30
3.00
2.70
2.40
2.10
1.80
1.50
1.20

fact that the large herds were owned by relatively wealthy farmers who had invested a considerable percentage of their capital in buildings.

Equipment (Graph III). The average annual equipment charge is a little over a dollar per cow. In one case, where but six cents were charged, no separator was used; in another case, where $4 was charged to a herd of four, the milk was separated and the cream taken to the creamery. Aside from the very small herds, the cost of equipment seemed to be a fairly constant factor.

Bedding (Graph IV). The cost of bedding depends upon local conditions and particularly upon the distance of the farm from the sawmill. The curve is erratic and its windings probably mean very little.

Bull (Graph V). The number of cows in the herd is the determining factor here; and the more the cows the less the cost, as the downward trend of the curve shows.

Interest. This was determined largely by the average cow valuation. In two herds, composed of registered Jerseys, the charge was a relatively high one, averaging about $3.25.

Depreciation. This varies widely, owing to diverse ideas on the part of the farmer, the average for 1503 cows being $4.49.

Taxes. The average grand list value of 1547 cows was $31.37; the average tax rate, $1.65; and the average tax, 52 cents per cow.

Insurance. As has been already remarked, this covers the cow and her share of the barn and amounted with 168 cows to 27 cents per survey to individual cases.

The total average cost of keeping a cow, exclusive of feed (Graph VI) was found to be $36.87, with maxima and minima ranging from $53.59 to $19.18. The graph indicates clearly the relation of the size of the herd to the total cost of maintaining a cow exclusive of feed. The high cost of keeping small herds is clearly shown and the fact that the cost tends to decrease until the herd is about 35 in number. The maintenance costs in the larger herds (few in number in this survey) are increased mainly because the work is done largely by hired help, the buildings are more expensive, the equipment better and the stock more valuable.

Feed. Data were secured as to the cost of feeding 2,319 cows. Hay was rated at from $8 to $12 a ton, the average being $10; silage at from $2.50 to $3.50; pasturage at from $4.50 to $5 per season; and concentrates at approximately $30 at the feed store. The cartage costs could not be estimated, as it is difficult to separate them from the cost of hauling other materials. However, it is, of course, a factor which should be borne in mind if one attempts to apply the results of this survey to individual cases.

The feed costs in 58 herds totalling 1,170 cows, in six localities visited by the writer, were found to be as indicated in the latter portion of the table on page 26, so far as maxima and minima are concerned. The averages shown in this table represent the records of 2,319 cows, including the 1,170 above indicated as well as 1,161 included in herds whose owners the writer was not able to interview.

Assuming that $42.18 represented the cost of feeding the average cow in this survey in 1911 and 1912, and that $36.87 represented the average cost incurred for labor, shelter, etc., as set forth on page 25, it seems fair to assume that the average total cost of keeping a cow in these 71 herds in 1911 and 1912 approximated $78.95, 53 percent of which sum was chargeable to feed, 24 percent to labor, 6 percent to shelter, 6 percent to depreciation, 4 percent to interest, 3 percent to the cost of keeping the bull, 2 percent to bedding and one percent each to equipment, taxes and insurance (see circle, page 37).

It now seems pertinent to inquire whether or not $78.95 was a reasonably accurate charge for keeping a cow in 1911 and 1912 in Vermont. It may be fairly assumed that the records of the cow test associations were essentially correct and that the validity of the feed costs cannot be gainsaid. Can as much be said as to the accuracy of the remaining factors?

Labor. The average cost of labor per cow was stated to be $18.82 when rated at 15 cents an hour. This allows only 20 minutes daily per cow for milking, feeding, etc. The average farm hand does not milk more than eight cows an hour. This leaves only five minutes per cow, or less than two hours for a herd of 20, for watering, stable cleansing, grooming, mixing grain, pitching hay and silage and for actual feeding operations. The writer doubts whether so much work can be done in this time and done well. He believes that a labor cost estimate of $24 is more nearly accurate. This is equivalent to 26 cents daily per cow.

Shelter. The writer believes that the estimates of the owners were as good as any which could be obtained, and considers that $4.93 is a fairly satisfactory charge.

Valuation of the cows. The average figure was found to be $53.7 Cows were selling in 1911 and 1912 at from $35 to $100. About 1 percent of the animals included in this survey were registered. Th figure does not seem to be an excessive estimate.

Depreciation. The average dairy usefulness of a cow after her fir calving is not more than seven years. She may then be worth $25 beef. Subtracting this sum from the average value above given, leav $28.79, or $4.11 per year depreciation charge for seven years, whi

compares fairly well with the farmers' estimates of annual depreciation, $4.49 per cow, which, however, includes loss due to death, accident, and disease, as well as age. Thirty-eight cents seems hardly enough to allow for these subsidiary losses.

Bedding, bull, taxes, etc. These items are of relatively little importance, and the figures appear to be reasonable.

THE INCOME

As an offset against the charge of $78.95 as the cost of keeping a cow, she may be credited with her calf, the manure and with either the milk or with the butterfat and skim- and buttermilks she produces.

Calf. The average calf when dropped is worth but little more than its skin, which sells for from 75 cents to $2. A rating of a dollar for the skin seems fair, particularly in view of the fact that abortion often occurs and that the cow sometimes fails to breed.

Manure. It is difficult to place any satisfactory valuation upon manure. To attempt to limit it to the money value of equivalent amounts of plant food is fallacious, for it ignores the many beneficial effects of manure upon the soil in ways other than the increment of its plant food content. The kinds of crops which are to be grown and the inherent fertility of the soil to which it is to be applied are important factors. Manure used on a farm in poor condition is worth more than if applied to a field in good heart. It is worth more when applied to non-legumes than to legumes. Any attempt to make a valuation of manures is more or less of a "leap in the dark." Perhaps as safe a figure as can be used is a dollar a ton at the barn. Eight tons may be taken as an average of the voidings at the barn during the year. The value of the pasture droppings may be ignored.

Allowing, therefore, $1 for the calf and $8 for the manure, we have a net charge of $69.95 against the average cow in this survey. What milk and fat yields did she make to offset this expense?

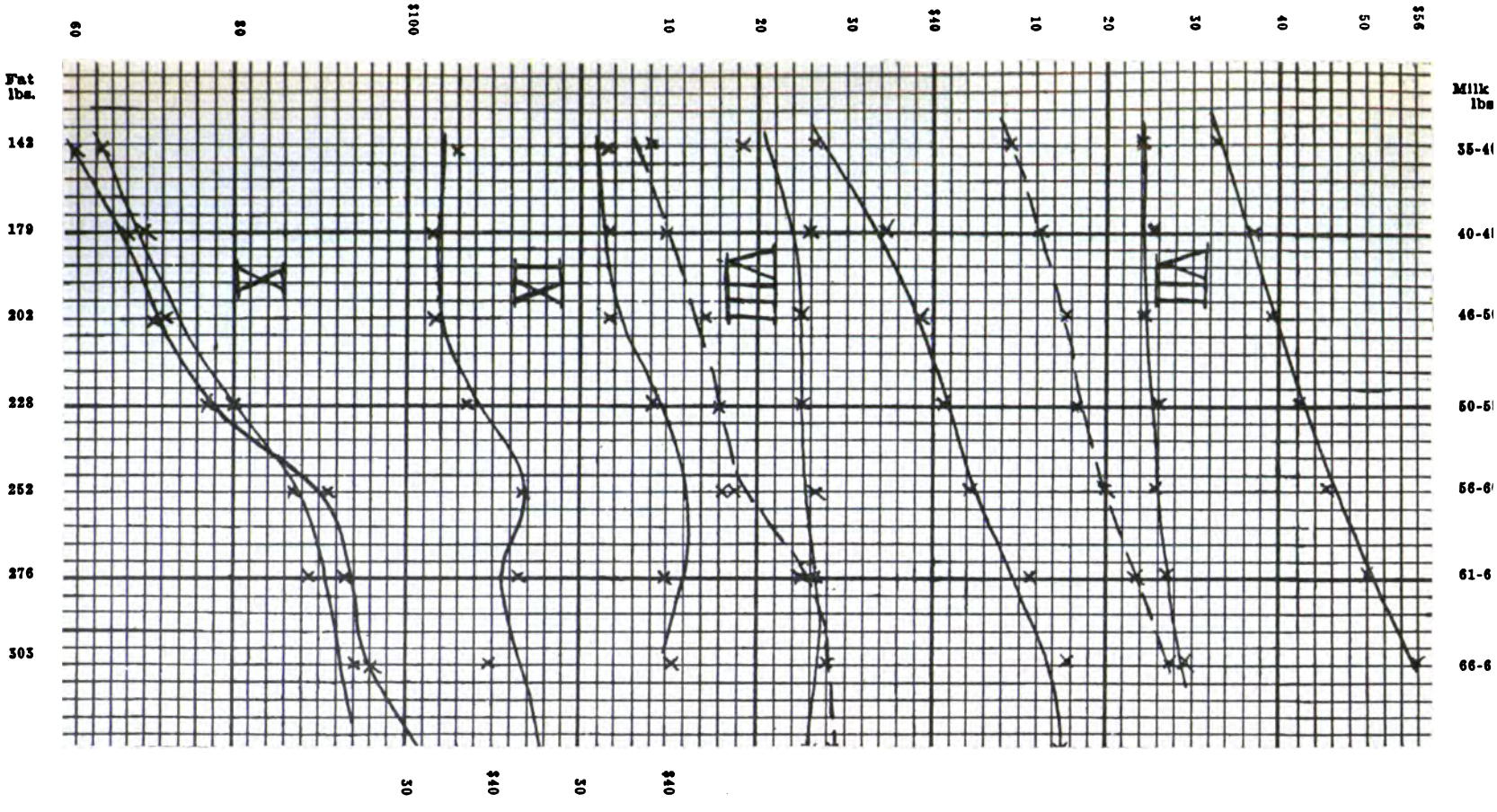
The yields in 58 herds, the owners of which were personally visited by the writer, may be summarized as follows:

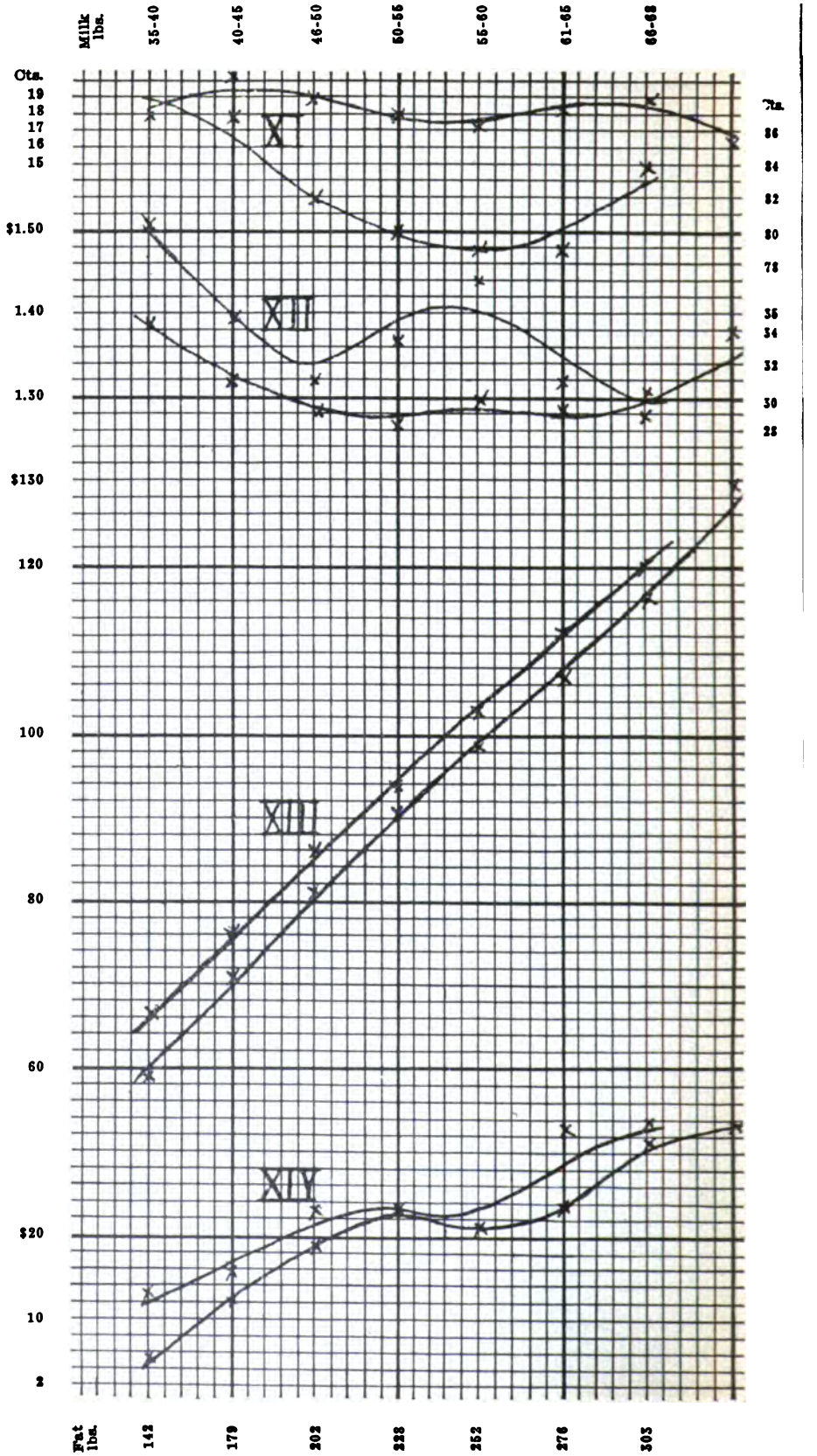
	Maxima	Minima	Average
Number of cows in herd	55	4	20.2
Milk yield per cow; lbs.	6,822	3,512	5,157
Fat yield per cow; lbs	349	142	242
Feed cost per cow	$ 65.34	$21.35	$42.42
Cost other than feed per cow	$ 53.59	23.32	37.57
Total cost of keeping a cow	$111.10	57.88	79.99
Total cost of keeping a cow, less calf and manure values	$102.10	48.88	70.99
Feed cost of producing a pound of fat	22cts	11cts	17cts
Total cost of producing a pound of fat	38cts	22cts	29cts

The production of these herds and the relationship of their size to the economy of production are shown numerically in the two accompanying tables and graphically in graphs VII to XIV. It may be remarked in passing that the quality of the milk seemed to increase slightly as the milk-flow was augmented; that is to say, in these particular herds, practically all which gave milk containing at least 4.5 percent fat and some of which gave milk carrying a 5 percent fat content, speaking broadly those which tended to give the most tended to give the best milk, which is not the situation usually found. The cows whose records were used in the present study were mostly grade Jerseys and more than 10 percent of them were registered Jerseys, which accounts for the uniformly high test.

Milk or Fat Yields	Number of herds in group	Roughage	Grain	Total food	Maintenance cost, other than food	Total cost of keeping a cow	Total cost of keeping a cow (less calf and manure)	Food cost of 100 lbs. milk or one pound butter fat	Total cost of 100 pounds milk or of one lb. butter fat	Income: $1.60 per 100 lbs. milk; 33 c. per lb. fat, 30 c. per 100 skim. and buttermilk	Income exceeds total cost less calf and manure
3512 to 3955	4	$23.96	$ 8.56	$32.52	$32.35	$64.87	$53.87	$ 0.87	$ 1.51	$67.32	$13.45
4062 to 4485	10	25.00	12.14	37.14	32.92	70.06	61.06	0.87	1.40	76.86	15.80
4590 to 5000	8	24.02	15.40	39.42	32.96	72.38	63.38	0.82	1.32	86.40	23.02
5007 to 5484	18	25.70	16.46	42.16	37.82	79.98	70.98	0.80	1.37	94.32	23.34
5507 to 5961	9	25.36	19.83	45.19	46.34	91.53	82.53	0.79	1.44	103.14	20.61
6095 to 6464	5	26.83	23.14	49.97	39.67	89.64	80.64	0.79	1.32	113.40	32.76
6554 to 6822	4	29.10	26.80	55.90	40.09	95.99	86.99	0.84	1.31	120.60	33.61
Graph reference		VII	VII	VII	IX	X		XI	XII	XIII	XIV
142 to 163	2	$18.30	$ 8.03	$26.33	$35.78	$62.11	$53.11	17	34.5 cts	$58.94	$ 5.83
179 to 194	7	24.14	9.39	35.53	32.51	68.04	59.04	19.5	31 "	71.20	12.16
202 to 224	12	24.72	13.86	38.58	32.91	71.49	62.49	18	29 "	81.70	19.21
228 to 250	15	25.37	15.63	41.00	36.14	77.14	68.14	17	28.5 "	91.65	23.51
252 to 274	10	26.50	17.53	44.03	43.01	87.04	78.04	16.5	30 "	99.66	21.62
276 to 297	6	25.66	25.11	50.76	42.26	93.02	84.02	17.5	29.5 "	107.76	23.74
303 to 312	4	28.01	27.71	55.72	38.76	94.48	85.48	18	29 "	116.34	30.86
349	2	25.99	28.27	54.26	52.13	106.39	97.39	15.5	34 "	129.78	32.39
Graph reference		VIII	VIII	VIII	IX	X		XI	XII	XIII	XIV

Food costs and milk yields (Graph VII). The relationship is set forth of the cost of food to the milk yields in herds making amounts of milk varying from about 3,500 to about 6,800 pounds per cow, grouped in seven lots at 500-pound intervals. It will be noted that all three lines, roughage, concentrate, and total, slant upwards, as might be expected, for a quart of milk is made only at the cost of food and the more the milk the more the food and the more the cost. The roughage costs rise very slightly, the increase in grain usage seeming to be the essential factor in the gain in production, in so far as food is a factor.


60
80
$100
10
20
30
$40
10
20
30
40
50
$56
Fat lbs.
142
179
202
228
252
276
303
Milk lbs
35-4
40-4
46-5
50-5
56-6
61-6
66-6
30
$40
50
$40


Milk lbs.
35-40
40-45
45-50
50-55
55-60
61-65
66-68
Cts.
19
18
17
16
15
$1.50
1.40
1.30
$130
120
100
80
60
$20
10
2
XI
XII
XIII
XIV
Fat lbs.
142
179
203
228
252
276
305

Food costs and fat production (Graph VIII). The relationship of food costs to fat production in the several groups of cows, whose yields varied from 150 to 350 pounds in nine lots grouped at 25-pound intervals is similar in its character to that shown in the preceding paragraph, and the general outcome is much the same.

Maintenance costs (Graph IX). The total maintenance costs other than food charges in the herds in the several groups are shown. These costs are essentially alike in the herds making the lower yields, tending gradually to increase thereafter.

Total costs (Graph X). The total cost of keeping a cow in these several groups is made manifest. The lines in the graph run consistently uphill, for the reason that food charges increased by regular gradations as did, in a general way, the maintenance charges other than food.

Food costs per unit of production (Graph XI). The food costs of making 100 pounds of milk and one pound of fat are shown. The cost of making 100 pounds of milk tends to decrease as yields increase, notwithstanding the increased food costs. This line declares aloud that it pays to feed good cows liberally. The differences in the fat curve seem less than in the milk curve, but really are about as great relatively. The figures are smaller. If the comparison was made on the basis of the cost of making five pounds of butter, and 100 pounds of this milk would make about five pounds of butter, the divergencies would be as large in one case as the other.

Total costs per unit of production (Graph XII). The total cost of making 100 pounds of milk or a pound of butterfat is made clear. The same questions may be raised as in the previous case as to the deceptive nature of the fat curve. Speaking in general terms, however, it is clear that the trend is toward a more economical production as the herd increases in its size.

In attempting to determine whether or not a profit was secured, obviously some norm must be chosen. It seemed, after careful consideration of the whole proposition, that it was advisable to use the following figures for the reasons stated. It should be remembered that this study covered records taken in 1911 and 1912 and has no immediate bearing upon present-day conditions, which everybody knows are quite unlike those obtaining five years ago.

Milk. $1.80 a hundred, the average price received for delivered milk by 60 wholesalers of bulk market milk in Burlington in early 1914 (see page 45).

Butterfat. 32 cents a pound, the average price paid at the creameries to which most of the milk (or cream) was taken from the herds under observation.

Skimmilk and buttermilk. 30 cents a hundred, an arbitrary figure but probably a fairly safe one for conditions obtaining in 1911 and 1912.

The milk averaged to contain 4.7 percent fat, which at 32 cents was worth $1.504; 85 pounds skimmilk per 100 pounds milk at 30 cents was worth 25.5 cents, making fat and skim worth $1.76 as compared with whole milk at $1.80. If to this figure is also added three cents for 10 pounds buttermilk, the two figures are almost exactly coincidental—$1.79 and $1.80.

Income (Graph XIII). This graph, predicated on the bases just indicated, looks like a single-track railroad headed northeast. However the parallelism means nothing, the lines are entirely unrelated. The two sets of groups, one on the milk yield basis and one on the fat yield basis, are not identical. The rocket-like ascension of the lines is the important point to bear in mind.

Gains (Graph XIV). The gains, based on the assumptions above indicated, are set forth in this graph. The gains on both bases at the outset and at the end of the lines are pronounced, but in the middle the lines flatten out. The plus sign is in evidence in all cases, but in some groups a large share of the profit is to be found in the value of the calf and the manure.

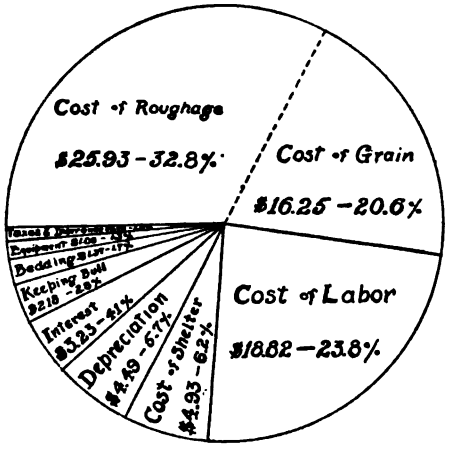
The salient features of this study, so far as they relate to averages rather than to the trend when the herds were segregated according to their productive capacities, are set forth in the three circles on the next page. The left hand circle indicates the distribution of cost of production; the middle circle the distribution of the income as between the main product (milk; or fat, skimmilk and buttermilk) and the manure and calf; and the right hand circle the nature of the net income, and its relation to the cost and the gross income. They tell their own stories.

Finally three things should be remembered:

1. That this study pertains to the conditions obtaining in 1911 and 1912 and not to those of 1916 and 1917.

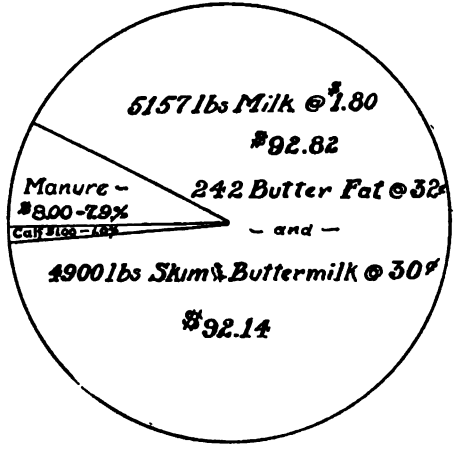
2. That the herds were better than the common run. The average fat production, 242 pounds, equivalent to nearly 300 pounds of butter, is far above the mean.

3. That if 1916-17 prices were used and if average cows had been employed, a much less favorable outcome would have been secured.



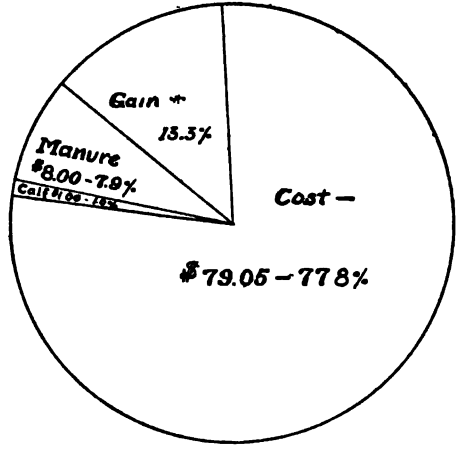
Cost of production.

(See table, page 25).



Income; distributed; main and by-products.

(See reading matter and table, page 31).



Net income; cost; gross income.

In this connection it may be remarked that in July, 1915, the Committee on Agriculture of the Boston Chamber of Commerce issued an analysis of the production, transportation, inspection and distribution of milk and cream in New England, based on an exhaustive investigation made in late 1914, wherein some 2,500 farmers were interrogated in the six New England states. The cost items were the same as those used in the present study save that "equipment" was not included but "incidentals—light, medicine, veterinarian, tools, heating, water in winter, salt, etc." were included, the one being about an offset to the other. This committee reports great variation in the estimates of the cost of keeping a cow and of making a quart of milk; and that there is lack of accurate knowledge as to the cost of production among farmers, due partly to temporary and partly to permanent causes. It hazards no guess as to the cost of producing a quart of milk.

Further, it should be noted that the State Commissioner of Agriculture in an address on "The Milk Situation in Vermont" delivered before the Health Officers' School in July, 1916, stated that "in 1914 we had in Vermont 25 cow-testing associations which obtained records of production of milk and butter fat and feed costs for 13,000 cows. When conservative estimates are supplied for cost of labor, interest, insurance, depreciation, barn rent, keep of bull and other incidentals, we find that the cost of keeping a cow like the average of the 13,000 was $98.25 per year. This average cow produced 5,087 pounds of milk or 2,364 quarts. If we deduct from the cost of keeping, $15 for manure and $2 for calf, we have an average cost of production of 3.4 cents per quart of milk. I believe that these figures represent what it is costing our best dairymen, who have good cows and who are taking good care of them, to produce milk. I find that dairymen who are selling milk in our Vermont towns and cities at 6, 7 or 8 cents per quart are fairly prosperous. I have yet to find, however, a dairyman who was satisfied to sell milk which costs 3.4 cents per quart to produce for 3.2 cents, which was the average price paid by Boston milk contractors in Vermont for the year 1914.

Many say that these figures are not in accordance with the facts, because our farmers are supporting their families and some of them are saving money. I maintain that this result is accomplished only by doing the work in connection with the dairy before and after a normal day's work, by possessing some capital upon which no interest has to be paid, or by producing feed at less than the market price. If an accurate charge is made for all items which enter into the cost

of producing milk the account will show no profit at the prices paid by the city contractors. Notwithstanding this, however, Vermont farmers may continue to produce milk on the basis that it is better to work for small wages during the morning and evening hours and during the winter season than not to work at all and also on the basis that the fertility of the soil will be improved by feeding on the farms the crops produced, but unless there is the stimulus of profit we cannot expect the dairyman to take that interest and pride in his business which are essential to the production of a good, clean, wholesome product."

THE INFLUENCE OF THE SIRE ON THE HERD

BY J. H. WILSON

For 20 years the station herd consisted essentially of grade Jerseys, either purchased, mostly in the towns of Brookfield and Randolph, or home-raised. The herd was headed during this time by four registered Jersey bulls, namely:

I. Earl of Montague, A. J. C. C., 25,009. (Sire, Young Pedro, 9,033, dam, Sultane Pogis, 42,157; half brother of Eurotissima, great grandson of Eurotas, great grandmother, a full sister of Mary Anne of St. Lambert). Used from 1896 to 1898.

II. Mint Tenth of Hood Farm, A. J. C. C., 51,177. (Sire, Mint, 23,600; dam, Shrine, 59,627). Used from 1899 to 1901.

III. Colonel Cassius, A. J. C. C., 60,567. (Sire, Gaffar, 37,346, dam, Woodstock Princess, 91,549). Used from 1901 to 1909.

IV. Golden Woodstock, A. J. C. C., 71,901. (Sire, Corrina's Norman, 63,812, dam, Garfield's Black Princess, 97,555). Used from 1905 to 1914.

Comparisons have been made of the records of the daughters of these bulls and of their dams with a view of determining so far as might be what effect, if any, the bulls had on the performance of their offspring. Each bull at the time of purchase was thought to be a superior animal and, from the standpoint of pedigree, should have done good service.

The comparisons were made in four ways:

I. By comparing the summations of the average yearly records made by dam and daughter regardless of age. For example, the average of eight years' records made by Pomona, the dam, and of 10 years' records made by Santa Rosa, the daughter of Pomona and Earl of Mon-

tague, were compared, as well as eleven other similar records of the Earl's daughters and their dams.

II. By comparing the summations of the average yearly records made by dam and daughter at the same average age, usually from four to six years of age. For example, an average of two years' of record made by Pomona when six and seven years old and of two years' of record made by Santa Rosa when five and six years old were compared, as well as eight other similar records of the Earl's daughters and their dams.

III. By comparing the summation of such few records as were available for animals, dam and daughter, averaging about seven and one-half to eight years of age; a method similar to that described in the last paragraph save that the numbers necessarily were restricted and the animals were mature instead of being relatively young.

IV. By modifying the results attained by method I as stated above by the use of correction factors. Method I is obviously open to the objection that the dams are advantaged in that their average production was made when they were approximately seven years old, whereas that of their daughters was made when they were approximately four and one-half years old. Now in a somewhat extensive study of the effect of age upon the quantity and quality of milk, published in the nineteenth report of this Station (pp. 339-350), using the same herd the record of which has contributed to the survey now in hand, the conclusion was reached that so far as the fat percentage was concerned, "heifers strike their gait * * * * * in the first lactation," and that, so far as milk yields were concerned "until the average cow was seven years old the general tendency was for the flow to increase in volume * * * * and that from the ninth year onwards the trend was downwards." The average cow in this herd for a long series of years made about 5,250 pounds of milk when in her fourth year and about 5,600 pounds when in her seventh year, an increase of 350 pounds. Similarly the butterfat yield was about 19 pounds greater when the cow was seven years old than it was when she was four years old. By arbitrarily adding the figures 350 and 19 to the milk and fat yield records of the daughters as shown under I, it may be assumed that, after a fashion, the disparity caused by immaturity may be obviated.

The following tabulations set forth the salient results secured by these four methods of calculation.

Earl of Montague, A. J. C. C., 25,009

	I	II	III	IV
Number of daughters	12	9	3	
Dam's records used	72	19	12	
Daughter's records used	61	21	12	
Average dam's age	7½ yrs.	6 yrs.	7½ yrs.	
Average daughter's age	5¼ yrs.	5½ yrs	7½ yrs.	
Average milk yield of dam	5,804 lbs.	5,862 lbs.	6,089 lbs.	5,804 lbs.
Average milk yield of daughter	5,004 lbs.	5,449 lbs.	5,238 lbs.	5,354 lbs.
Average increase, dam over daughter	+800 lbs.	+413 lbs.	+851 lbs.	+450 lbs.
Average fat yield of dam	300 lbs.	321 lbs.	328 lbs.	300 lbs.
Average fat yield of daughter	253 lbs.	282 lbs.	260 lbs.	272 lbs.
Average increase, dam over daughter	+ 47 lbs.	+ 39 lbs.	+ 68 lbs.	+ 28 lbs.
Average fat percentage, dam	5.17%	5.48%	5.39%	
Average fat percentage, daughter	5.06%	5.18%	4.99%	
Average increase in fat percentage, dam over daughter	+0.11%	+0.30%	+9.40%	

Mint Tenth of Hood Farm, A. J. C. C., 51,177

	I	II	III	IV
Number of daughters	7	6	2	
Dam's records used	42	14	6	
Daughter's records used	27	14	6	
Average dam's age	7 yrs.	4½ yrs.	7½ yrs.	
Average daughter's age	4½ yrs.	4 yrs.	7 yrs.	
Average milk yield of dam	5,548 lbs.	5,315 lbs.	6,376 lbs.	5,548 lbs.
Average milk yield of daughter	3,712 lbs.	3,877 lbs.	5,281 lbs.	4,062 lbs.
Average increase, dam over daughter	+1,836 lbs.	+1,438 lbs.	+1,095 lbs.	+1,486 lbs.
Average fat yield of dam	310 lbs.	303 lbs.	365 lbs.	310 lbs.
Average fat yield of daughter	216 lbs.	233 lbs.	286 lbs.	235 lbs.
Average increase, dam over daughter	+ 94 lbs.	+ 70 lbs.	+ 70 lbs.	+75 lbs.
Average fat percentage, dam	5.59%	5.70%	5.72%	
Average fat percentage, daughter	5.83%	6.00%	5.41%	
Average increase (+) or decrease (—) in fat percentages, dam over daughter	—0.24%	—0.30%	—0.31%	

COLONEL CASSIUS, A. J. C. C., 60,567

	I	II	III	IV
Number of daughters	22	20	4	
Dam's records used	158	54	12	
Daughter's records used	86	83	12	
Average dam's age	7½ yrs.	5½ yrs.	7¾ yrs.	
Average daughter's age	4½ yrs.	4¼ yrs.	7½ yrs.	
Average milk yield of dam	5,417 lbs.	5,478 lbs.	5,218 lbs.	5,417 lbs.
Average milk yield of daughter	4,304 lbs.	4,323 lbs.	5,011 lbs.	4,654 lbs.
Average increase, dam over daughter	+1,113 lbs.	+1,155 lbs.	+ 207 lbs.	+ 763 lbs.
Average fat yield of dam	289 lbs.	298 lbs.	261 lbs.	289 lbs.
Average fat yield of daughter	253 lbs.	253 lbs.	290 lbs.	272 lbs.
Average increase (+) or decrease (—) dam over daughter	+ 36 lbs.	+ 45 lbs.	— 29 lbs.	+ 17 lbs.
Average fat percentage, dam	5.33%	5.44%	5.00%	
Average fat percentage, daughter	5.86%	5.86%	5.85%	
Average decrease (—) dam over daughter	—0.53%	—0.42%	—0.80%	

GOLDEN WOODSTOCK, A. J. C. C., 71,901

	I	II	III*	IV
Number of daughters	13	10		
Dam's records used	76	17		
Daughter's records used	32	28		
Average dam's age	6 yrs.	4 yrs		
Average daughter's age	3¼ yrs.	3½ yrs.		
Average milk yield of dam	5,336 lbs.	4,567 lbs.		5,336 lbs.
Average milk yield of daughter	4,616 lbs.	4,364 lbs.		4,966 lbs.
Average increase, dam over daughter	+ 720 lbs.	+ 203 lbs.		+ 370 lbs.
Average fat yield of dam	265 lbs.	231 lbs.		265 lbs.
Average fat yield of daughter	261 lbs.	246 lbs.		280 lbs.
Average increase (+) or decrease (—), dam over daughter	+ 4 lbs.	— 15 lbs.		— 15 lbs.
Average fat percentage, dam	4.96%	5.07%		
Average fat percentage, daughter	5.65%	5.64%		
Average decrease, dam over daughter	—0.69%	—0.57%		

*Only one daughter mature enough to furnish record.

It should be said, before an attempt is made to draw conclusions from these data, that the bulls were disadvantaged in the following respects:

1. Speaking broadly, the cows which remained permanently in the herd, whose records contribute to the summations appearing on the dam's side, were those which had proved their dairy worthiness, whereas many of the daughters whose records contribute to the summations

on the opposite side were discarded because of inferiority after one or two years of record making. Using the parlance of Wall street, practically all the dams were "preferred stock," whereas many of the daughters were "common stock," the one returning quite certain dividends, the latter problematic dividends. One is reminded of the story of the adopted child who looked down upon her playmate because the latter's "papa and mamma had to take her just as she came, whereas she (the adopted child) had been chosen out of thirty." The dams were the chosen, whereas there were several culls among the daughters. To have been absolutely fair to the bulls, all the daughters of all the cows should have been kept and bred indefinitely, whereas some were sold as calves, some kept for a while and sold after one or more lactations, and some kept for several years. It cannot be denied that this is an important factor and that both should be accorded weight in the formation of a decision as to the value of these bulls.

2. The exigencies of feeding trials, during which in some cases somewhat deficient rations were purposely fed, may have affected the outcome. The writer does not believe that this is all important, but it may have been a subsidiary, item for consideration.

Bearing these limitations in mind, the results may be summarized as follows:

Earl of Montague. His daughters gave less and poorer milk than their dams.

Mint Tenth of Hood Farm. His daughters gave very much less milk than their dams, which tended to be somewhat richer in quality.

Colonel Cassius. His daughters gave much less milk than their dams, but it was of distinctly better quality.

Golden Woodstock. His daughters gave less milk than their dams, but it was enough richer so that the fat yields made by the daughters were as good as or better than those of the dams.

Bearing in mind the handicap above referred to, it is the writer's judgment that on the whole the bulls may be rated as follows:

Earl of Montague—slightly unsuccessful.

Mint Tenth of Hood Farm—a serious detriment.

Colonel Cassius—somewhat unsuccessful.

Golden Woodstock—fairly successful.

In this connection it may be noted that a similar study was made at the Pennsylvania Station and cited in its report for 1907, wherein it was developed that the daughters of three bulls were better, of one no better, and of one decidedly poorer than their dams in production. Similarly at the Missouri Station, a survey of the use of six bulls

showed that the daughters of two were much better, of two much poorer, and of two neither better nor poorer than their dams in milk and fat production. Circular 135 of the Ohio Station cites the records of two bulls, one of which seemed a bane and the other a blessing to the herd.

CONCERNING THE BURLINGTON MILK SUPPLY

By J. E. CARRIGAN AND W. T. ABELL

The Federal Department score card was used at 74 dairies where market milk for sale in Burlington was being produced in 1914, with results as follows:

Score	Numbers
75 to 70	4
69.9 to 65	6
64.9 to 60	13
59.9 to 55	10
54.9 to 50	14
49.9 to 45	14
44.9 to 40	10
39.9 to 35	3

Average score 54.2.

Speaking broadly, the cows scored better than did the stables, utensils and milk room; and the handling of the milk after it was secured seemed to be better than was the care of the cows, of the stables, of the milk room, of the utensils or the milking process. In short, bovines seemed to outclass humans. The consistent service of the local milk inspector which is now in vogue will doubtless be effectual in bettering some of these conditions.

The delivery system was found to be quite unsatisfactory. Fourteen routes were traced on the Burlington street map with interesting results. For example, a few typical short streets which are not thoroughfares were thus served: Buell street (one block), 6 teams, 29 houses; Bay View street, 3 teams, 7 houses; East avenue, 3 teams, 23 houses; North Prospect street (one block), 5 teams, 13 houses; Decatur street, 3 teams, 19 houses; Green street, 5 teams, 30 houses. On the other hand, there were several long stretches of street served by only one or two teams, while entire sections were apparently unserved, doubtless securing their supplies from small grocery stores. This duplication of effort explains in part why milk now retails in Burlington at nine cents a quart; and of course it is entirely typical of the situation obtaining throughout the land.

Six main factors enter into the cost of retail milk delivery, namely: man labor, team labor, bottle breakage and loss, equipment depreciation, repairs, and interest and taxes. The estimates of nine Burlington milk retailers for these items were collated, showing that the cost of delivering a quart of milk varied from 0.9 cents to 3.2 cents, averaging 2 cents. Labor costs made up 80 percent and bottle loss and breakage more than 10 percent of the total. The low delivery cost —0.9 cents— was on a 600 quart route; the high delivery cost—3.2 cents—on a 90 quart route, the equipment for which was nearly as extensive and expensive as that used in the larger business. The "distribution to family trade" cost in Greater Boston was stated by three contractors selling in that region to be 3, 3.86, and 2.35 cents per quart (Boston Chamber of Commerce Report, "Investigation etc. of Milk and Cream in New England," page 30, July, 1915). There is nothing new in these findings. The situation is common everywhere.

Sixty wholesalers sold to retail delivery men or to hotels, restaurants, boarding houses and stores. The overhead charges incident to this system of distribution are less than those incurred in the retail business. Bottle breakage and loss, equipment depreciation, interest on investment, etc., are practically eliminated, the delivery of the bulk milk being practically the only cost above production charges. These wholesalers were selling in early 1914 at from $1.50 to $2.25 per hundred pounds. From 25 to 400 quarts were delivered, and delivery costs per quart naturally varied. In a few cases they were nil, the milk being gathered at the farm; in some cases they were excessive. For example, in one case it took a man and a two horse team one hour to deliver 42 quarts, costing more per quart to make this single delivery than it cost some retailers to make their hundreds of deliveries. The wholesale deliveries cost on the average a small fraction over one cent a quart. Data pertinent to the question of the cost of Boston wholesale deliveries derived from the Chamber of Commerce report above cited, furnished by some of the large contractors, were: To retail stores, 1 cent; 1.5 to 2 cents; 2.05 cents; 0.95 cents; to wholesale trade, 0.5 cents; 0.47 cents; 1.13 cents per quart.

Assuming a 3-cent per quart production charge which is doubtless somewhat too low a figure for the time when the thesis was written and of course far too low a figure for the conditions obtaining in 1916 and 1917, and a 20-cent per hour labor charge per man and per horse, it would appear that the following statements might hold for the sale of Burlington bulk milk in early 1914:

				Number making a profit	Number making no profit	Number making a loss
11	producers	sold	50-100 pounds	2	2	8
8	"	"	101-150 "	4	3	1
14	"	"	151-200 "	6	7	..
6	"	"	201-250 "	2	4	..
4	"	"	251-300 "	3	1	..
3	"	"	301-350 "	3	..	..
8	"	"	351-400 "	8	..	..
6	"	"	401-850 "	5	1	..
	Totals			33	18	9

It would seem that, roughly speaking, half the milk wholesalers were making a profit and half a loss on a 3-cent production basis. The two instances of profit shown in the first horizontal column represent cases where the milk was gathered at the farm thus eliminating the item of delivery charges, or where but a half hour's time was engaged in delivery, with sales prices well above the average. The one case of no profit on a large transaction represents a long haul, entailing a time expenditure of 3½ hours daily, and a sales price well below the average. If as a matter of fact it cost more than 3 cents to produce a quart of the grade sold—and the writer believes this figure is more apt to be low than high of the truth—obviously the wholesalers of market milk in the vicinity of Burlington were not getting rich rapidly in 1914.

There is a tendency nowadays looking towards the centralization of the distribution of milk, in order that a better and more uniform supply may be purveyed at less cost. A study was made of the possibility of establishing a central processing plant in Burlington, with results which may be concisely set forth as follows:

In 1914, 59 dairies supplied about 10,500 quarts daily, about a quarter of which retailed and three-quarters wholesaled. Nineteen percent came from the north of the City, 4 percent from the territory along Shelburne road, 10 percent from that along Dorset street. Two-thirds of the entire supply, exclusive of the 10 percent which enters over Dorset street, originates at points to the southeast of the City and enters it over the Williston turnpike. Seventy-four percent of the entire supply either passes by or within a half mile of the point suggested for the location of the central processing plant, as shown on the map. This place is on territory owned by the Mary Fletcher Hospital and is adjacent to a small spring-fed pond, 50 x 90, from which a portion of the ice supply might be obtained. The lake is two miles away, and the haulage of coal, etc., would be two miles. A plant so constructed as to handle the inevitable surplus, making sweet cream, butter, cottage

cheese, etc., would be worth while, since a good market would be found at its doors.

It is suggested that a building 65 x 100 x 40, with an annex 50 x 75 x 25 be erected, together with a two-story barn 100 x 60 and an ice house 40 x 50 x 20, with elevator. Here the assembled milk would be weighed, clarified, pasteurized, bottled or placed in cans, or made into sweet cream, butter, cheese, etc., as needed.

A careful survey of the delivery system now in vogue leads to the conclusion that six teams with drivers and two men would satisfactorily make retail deliveries in less than 3 hours, with auto collection trucks making wholesale deliveries to hotels (restaurants, stores and boarding houses); all this without material duplication in travel.

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MARCH, 1917 BULLETIN 203

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

"MONY MEIKLES MAK A MUCKLE" III

I. The Winter Storage of Roots,
by P. H. Aldrich.

II. Forcing Plants by Means of Warm Water,
by W. G. Bodine.

III. Concerning Quality in Celery,
by J. B. Norton.

IV. The Gnarly Apple Disease of 1914,
by W. H. Venable.

V. The Thermal Death Point of Yeast,
by E. P. Wells.

VI. Soil Sterilization,
by F. O. Ockerblad, Jr.

VII. The Cost of Producing Maple Products,
by C. J. Frink.

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Bulletin 170 was constructed from ten short articles, totaling 17 pages. It was said in the foreword of that bulletin that "no one of them is big enough to make a bulletin, yet in several of them, it is thought, there is material worthy of record." The same may be said of the seven articles printed in this issue and of the four included in its immediate predecessor, No. 202. In each case the article represents a brief of a thesis presented by graduates of the College of Agriculture of the University of Vermont in partial fulfillment of graduation requirements.

The briefs in each case have been made by the writer of this note, in consultation with his associates in whose several departments the work was originally carried on. In all cases the matter as originally presented has been more or less recast. Indeed, the language of the briefs is very largely that of the present writer. In all cases where the deductions rested upon mathematical data, these have been checked as to accuracy.

JOSEPH L. HILLS, Director.

THE WINTER STORAGE OF ROOTS

BY P. H. ALDRICH

Winter-stored roots are apt to be or to become dry, relatively tasteless and perhaps fibrous or corky. These changes are due to the natural processes of transpiration and respiration, to moisture evaporation and to fungal and bacterial attack. Can these conditions be remedied by modification in the preservation process?

Preliminary studies were made with carrots, beets, and parsnips, looking more especially toward the determination of the influence of temperature variations during storage, of media and of disinfectants upon such preservation, as well as of the nature of the modifications occurring in the vegetable structures during storage.

Temperature. Bushel lots of the roots were kept in cold storage, in a somewhat damp cellar at temperatures ranging from 38° to 70° F., and in living rooms.

Media. Lots ranging in size from 35 to 115 roots were used in these trials and were packed in alternate layers with either moist or dry sand, either moist or dry sawdust, in garden soil or wrapped individually in newspaper wrappers.

Disinfectants. The roots used in these trials were dipped either in bordeaux mixture or in mercuric chlorid (corrosive sublimate), or were immersed in paraffin.

The vegetables were harvested in October, left in the greenhouse cellar until November 12, when they were stored or otherwise treated, and then held until May 28, a period of 6½ months. They were then counted, weighed and graded as to soundness and uniformity of size, as was done also in November when the trials were begun. Edibility trials were made in each case when edible roots survived storage or other conditions, being cooked with the skins on for 35 minutes (carrots, parsnips), or 75 minutes (beets).

TEMPERATURE TRIALS

Cold storage. The results of the cold storage trials may be set forth in concise form as follows:

Carrots:	Weight loss		15	percent.	In good condition			40	percent
Beets:	"	"	6	"	"	"	"	82	"
Parsnips:	"	"	8	"	"	"	"	99	"

The carrots decayed badly, whereas only three of 78 beets and but one of 108 parsnips were unfit for table use. It should be said that because of ice shortage the temperature during the last month of storage was relatively high, and that on April 12, at which time the temperature had at no time exceeded 38° F., all the vegetables were in excellent condition.

Cellar. The results of the cellar trials may be set forth in concise form as follows:

Carrots:	Weight loss		48	percent.	In good condition			none	
Beets:	"	"	3	"	"	"	"	100	percent
Parsnips:	"	"	50	"	"	"	"	61	"

All of the carrots were decayed, although some might have served for home consumption; the parsnips were somewhat dried, and several were badly shriveled; while the beets, advantageously located as compared with the other roots and protected from air movements, survived in good condition.

Living room. The results of the living room trials may be set forth in concise form as follows:

Carrots:	Weight loss	100	percent.	In	good	condition	none	
Beets:	"	"	81	"	"	"	"	"
Parsnips:	"	"	78	"	"	"	"	"

The carrots were a mass of decay, while the beets and parsnips were as dry and hard as stones.

MEDIA TRIALS

The media trials furnished results which may be expressed as follows:

MOIST (SLIGHTLY DAMPENED) SAND

Carrots:	Weight loss	20	percent.	In	good	condition	52	percent
Beets:	"	1	"	"	"	"	100	"
Parsnips:	"	8	"	"	"	"	98	"

DRY (HEATED) SAND

Carrots:	Weight loss	24	percent.	In	good	condition	62	percent
Beets:	"	3	"	"	"	"	100	"
Parsnips:	"	21	"	"	"	"	100	"

MOIST (SLIGHTLY DAMPENED) SAWDUST

Carrots:	Weight loss	67	percent.	In	good	condition	27	percent
Beets:	"	6	"	"	"	"	100	"
Parsnips:	"	17	"	"	"	"	92	"

DRY SAWDUST

Carrots:	Weight loss	36	percent.	In	good	condition	57	percent
Beets:	"	28	"	"	"	"	81	"
Parsnips:	"	28	"	"	"	"	79	"

NEWSPAPER WRAPPERS

Carrots:	Weight loss	35	percent.	In	good	condition	41	percent
Beets:	"	18	"	"	"	"	93	"
Parsnips:	"	44	"	"	"	"	65	"

GARDEN SOIL (SLIGHTLY DAMP)

Carrots:	Weight loss	40	percent.	In	good	condition	28	percent
Beets:	"	0	"	"	"	"	98	"
Parsnips:	"	29	"	"	"	"	60	"

Moist sand. The carrots were decayed both at the crown and within; the other roots kept well.

Dry sand. The carrots kept well on the whole but such as were decayed were badly affected; the parsnips were a bit shriveled and not firm to the touch; the beets survived in good condition.

Moist sawdust. Most of the carrots were badly decayed; the parsnips were firm, clean and wholesome, with the exception of five which were moldy and softened; the beets seemed to gain slightly in weight.

Dry sawdust. The discarded carrots were decayed in the core, but the surrounding tissues were firm, well colored and seemingly edible; the rejected beets were shriveled and seemingly spongy; the parsnips kept well, but were favored by the location of the boxes.

Wrappers. The carrots decayed badly; the beets were not exactly firm to touch; and the parsnips were shiveled and somewhat moldy. The papers were damp, having apparently absorbed moisture from the roots which they enclosed.

Garden soil. The carrots were very badly deteriorated; a single beet showed a small decayed spot; and the parsnips were either very good or very bad, the latter being apparently infected.

DISINFECTANTS

The disinfectant trials resulted as follows:

Bordeaux (5-5-50); immersion for ten minutes followed by storage in the cellar.

Carrots:	Weight loss	58	percent.	In good condition			67	percent
Beets:	" "	29	"	" "		"	69	"
Parsnips:	" "	34	"	" "		"	78	"

Mercuric chlorid (1 tablet to 1 pint); three minutes immersion; placed in paper sacks in cellar storage.

Carrots:	Weight loss	60	percent.	In good condition			none	
Beets:	" "	64	"	" "		"	"	
Parsnips:	" "	75	"	" "		"	"	

Paraffin immersion; dipped at 42° C. and placed in paper sacks in cellar storage.

Carrots:	Weight loss	11	percent.	In good condition			none	
Beets:	" "	5	"	" "		"	100	percent
Parsnips:	" "	25	"	" "		"	20	"

Bordeaux. The carrots felt firm, but were somewhat shrunken, losing one-half their weight, the "good" ones, when cut, quite often appearing dry and spongy; the beets were soft and spongy, their outer tissues for a quarter inch being dry, while the residue was more succulent; and the good parsnips were firm, whereas many of those which were discarded were moldy.

Mercuric chlorid. All the roots were either shriveled or decayed. The parsnips were moldy, their mercury bath to the contrary not-

withstanding. Indeed, as a whole their lot fared no better than the lot exposed to living room temperature.

Paraffin immersion. All the carrots were decayed, whereas all the beets kept well; and the parsnips were for the most part either shriveled or decayed. The paraffin shells in all cases were perforated with many small holes, probably due to root respiration.

THE EFFECT OF STORAGE, OF MEDIA AND OF DISINFECTANTS ON THE MOISTURE CONTENTS OF THE ROOTS

Careful moisture determinations were made before and after storage. In general it may be said that the roots packed in dry media (sand, sawdust, wrappers) lost in weight; that those packed in moist media (sand, sawdust, soil) gained; that those placed in cold storage gained; and that those treated with disinfectants lost in weight. The moisture losses observed in these special trials were not commensurate with the losses observed in the regular trials, which would indicate that much of the loss in weight occurring during storage is of oxidized dry matter.

EDIBILITY TRIALS

The results as to the edibility of the stored and treated vegetables simply represent the personal judgment of the author of the thesis. That they were exact is not claimed, for his palate palled. However, in a general way they doubtless express the facts.

TEMPERATURE TRIALS

Cold storage:
Carrots—Tender and good.
Beets—A bit tough; flavor fair.
Parsnips—Tender; flavor fair.

Cellar:
Carrots—None left in edible condition.
Beets—Somewhat fibrous; not bad.
Parsnips—Somewhat fibrous.

Living room:
All the roots were inedible.

MEDIA TRIALS

Moist sand:
Carrots—Fibrous and tasteless.
Beets—Quite crisp and good.
Parsnips—Fairly good.

Dry sand:
Carrots—Tender and rather good.
Beets—Somewhat corky.
Parsnips—Cores tough.

Moist sawdust:
Carrots—Distasteful.
Beets—Crisp; good flavor; occasionally fibrous.
Parsnips—Tender; flavor sweet.

Dry sawdust:
Carrots—Tender and tasteful.
Beets—No record.
Parsnips—Fair; good flavor.

Newspaper wrappers:
Carrots—Tender; watery; flat.
Beets—Somewhat fibrous.
Parsnips—Not bad in texture.

Garden soil:
Carrots—Not very tender.
Beets—Tender and crisp.
Parsnips—Somewhat tough.

DISINFECTANT TRIALS

Bordeaux:
Carrots—Tender; well flavored.
Beets—Rather corky.
Parsnips—Tender; flavor fair.

Mercuric chlorid:
No edibility trials made—for obvious reasons.

Paraffin immersion:
Carrots—None left in edible condition.
Beets—Medium; not bad.
Parsnips—Tender; good flavor.

TRIALS WITH RADISHES

Greenhouse grown radishes were stored on March 12 as follows: in cold storage (refrigerator on ice)—wrapped in cheese cloth, both with tops on and off; in the cellar under similar conditions, as well as immersed in water both with tops on and off; and in the living room, immersed in water with tops on and off. The results as to preservation under these conditions may be set forth as follows:

Where	How	Tops	Length of preservation in fair edible condition
Cold storage	Cheese cloth wrapping	On	3 months
" "	" " "	Off	3 "
Cellar	" " "	On	1 "
"	" " "	Off	1 "
"	Tap water immersion	On	3 weeks
"	" " "	Off	3 "
"	Distilled water immersion	On	3 "
"	" " "	Off	3 "
Living room	Tap water immersion	On	10 days
" "	" " "	Off	10 "
" "	Distilled water immersion	On	10 "
" "	" " "	Off	10 "

In all cases the lots on which the tops were left kept better than those which had been topped.

STRUCTURE MODIFICATION

Do vegetables tend to become fibrous and corky toward the end of the winter—or is this simply a notion? Careful comparisons of the tissues of the three vegetables under study made in the fall and again in the spring after a six and one-half months' storage lead the writer of the thesis to conclude that there appears to be an increase in the amount of fibrous tissue following the winter storage in beets, but not in carrots and parsnips; that the apparent increased toughness and stringiness of the latter in the spring may be due to the thickened trachea tubes, although the correctness of this surmise was not demonstrated. In the case of the beet, however, it was quite clear that increases in fiber tissue occurred to a greater extent in the lots kept under dry than in those kept under moist conditions. This development seemed to be made at the expense of the surrounding companion and parenchyma cells.

THE FORCING OF PLANTS BY MEANS OF WARM WATER IMMERSIONS

BY W. G. BODINE

The effect of a warm water dosage on plant growth, buds, tubers, sets and seed, has been studied somewhat of late in Europe and in this country, and as a result of these investigations it has been proven that the resting period of many plants may be interrupted or shortened to advantage. Several agents have been used other than water; various anesthetics have been applied; plants have been frozen or desiccated. Studies of this character have particular pertinence in connection with floriculture, for florist's products have seasonal values. They are worth large sums if available on a certain date, for example, Christmas or Easter, and have less commercial values when these dates are past.

In the trials now being discussed, twigs of wild grape, elm, apple, basswood, cottonwood and a species of Rubus were gathered on February 10, thawed, and placed for four to eight hours in water, some at 36° C. and some at 7° C., and then placed in the greenhouse. The first leaves were observed on the twigs immersed in warm water from five to fifteen days sooner than they were observed on the twigs immersed in cold water, with all the species other than the apple. For some reason or other the growth of the apple twigs seemed retarded for a month. One can hardly fail to wonder whether or not through

some inadvertence the apple twigs were not shifted in the transfer to the greenhouse.

Stringless green pod bean seed was soaked for lengths of time ranging from 15 to 120 minutes in water which varied in temperature from 10° to 22° C. for the cooler water and 37° to 45° C. for the warmer water. The trials were made in the late fall and early spring. No gains were secured in the earliness or profuseness of growth as a result of soaking either in cold or warm waters as compared with untreated seed; and the same statement may be made touching the results of similar trials made with peas. Radishes grew a smaller top but a better root when the seed was immersed in water at from 38 to 41° C. for three-quarters of an hour than they did when the seed was either soaked in cold water or left untreated. Corn and oats grew better and somewhat larger crops when the seed was soaked at from 36 to 41° C. from four to five hours than when left untreated or when soaked in cold water, when these treatments were applied in the winter months; but no material response followed warm water treatment in the spring or summer, when, it may be assumed, the seed had gotten over its desire for rest and was ready to grow.

The author of this thesis states that temperatures from 30 to 36° C. seemed in most cases best adapted to experimental needs; that a soaking of from 7 to 12 hours for twigs and shrubby plants and of from two to five hours for seed seems optimum, longer exposures being deemed inadvisable; that in general late spring immersions proved relatively ineffective; that little water seems to be absorbed by twigs which are incited to early awakening and rapid development by warmth stimulus; that seed soaked in warm water absorb more water than do those soaked in cold water and that the seedcoats soften, thus probably inducing favorable results. He points out that the hastening of the slow growth of greenhouse plants in midwinter by some such process at times may be found worth while; and that especially such plants as lilac, syringa, forsythia, and azalia readily respond to warm water dosage and might thus be treated to commercial advantage.

CONCERNING QUALITY IN CELERY

By J. B. Norton

Quality in celery is primarily a question of the proportional relationships of the so-called parenchymous tissue to the fibrous tissue; and this is determined in part by varietal differences and, within

varietal limits, in the main by certain external conditions, such as soil moisture, plant food, rate of growth, light, warmth, pest control and blanching.

Celery contains 93 percent or more of water and its cells must be turgid if a crisp product is to be secured. A series of experimental trials wherein plants were grown in water or were given water in amounts ranging downward from 187 cc. to one cc. daily, resulted in no height growth, or, indeed, in shrinkage in height when 15 cc. or less were supplied daily, and increasing height growth when 31 to 187 cc. were used.

Being a foliaceous plant, celery responds more readily to soil dosages of nitrogen than to other forms of plant food. In a series of trials following the application of 0.25, 0.5 and 0.75 grams nitrate of soda, increases in height growths were secured roughly proportional to the fertilizer usage being, in 30 days: no nitrate applied, 2 inches; ¼ grain nitrate, 3½ inches; ½ gram nitrate, 4¾ inches; ¾ gram nitrate, 5¾ inches; and, furthermore, the more the growth the less the tendency toward stringiness. Similar results were obtained by the use of artificial mixtures of half sand and half humus-rich soil, and of one-third sand, two-thirds humus-rich soil.

The character and the quantity of parenchymous tissue is determined by the growth rate which in turn is governed largely by moisture and plant food opportunities. Slow or checked growths cause stringiness, and overrapid growth an excessively elongated and stringy growth.

Light is an important factor. Several plants were grown either in full light, in half light or in darkness. Intense light hindered growth and lack of light caused an abnormal etiolated growth. The full-lighted crop was dwarfed, stringy and tough, the half-lighted crop was of good quality, and the no-light crop was long stemmed, watery and subject to disease attack.

Temperature functions. Celery grows best in cool temperature. In a series of trials a crop grown at approximately 80° F. was shorter and far more leafy than one grown at 60° F., but its quality was not injuriously affected.

Blanching, if properly done, tends to develop a "nutty" flavor; if improperly done, a bitter flavor. In either case the chlorophyll is profoundly modified, or, indeed, destroyed.

"Pithiness" is characterized by lack of parenchyma. It has been shown at the Maryland station that this is due in the self-blanching

varieties to heredity, to the propagation of an undesirable strain or to reversion, but that in other forms it is quite as likely to be due to unfavorable cultural conditions. Careful seed selection should to a large degree obviate this difficulty.

THE GNARLY APPLE DISEASE OF 1914

By W. H. VENABLE

Apples in several sections of Vermont and New York were seriously troubled in 1914 by a somewhat unusual malady. The affected fruit was misshapen, depressed and indented, the flesh below but not in connection with the apex of the indentation being a mass of brownish, corky tissue. The skin was less affected than the outer pulp layers, which in the diseased area were pithy and tasteless. The fruit was sometimes but slightly unsymmetrical, and sometimes so gnarly and knotty as to be utterly worthless. These malformed specimens kept but poorly in storage as compared with normal fruit as evidenced by their greater tendency to rot and to shrivel. Neither fungi nor bacteria were found in the malformed areas nor were there clear evidences observed of insect attack. Indeed, the unusual nature of the injury would seem to preclude the likelihood of such attack, since no uncommon insect was observed in any quantities, but only those species which are always with us.

The author of the thesis, having carefully canvassed the whole situation and to his entire satisfaction eliminated the possibility of fungal, bacterial or insect relationship to this difficulty, became convinced that the trouble was due to a late May frost injury occurring coincident with the blossoming period, aggravated by the conditions brought about by a somewhat dry summer. The fruit blossoms in the experimental orchard on the University farm, in which 16 varieties are being grown, appeared on May 20 to 22, the full bloom was on May 25 and 26 and the petals fell May 27 to 29. The average temperatures from May 20 to 29 were: 50°, 51°, 57°, 45°, 39°, 53°, 68°, 66°, 52°, 45°. A little less than a tenth of an inch of rain fell on May 23. It will be noted that on May 24 the average temperature was extremely low. The Weather Bureau records show a sharp frost on that date following the rain. This occurred the day before the full bloom was on and some days after the first blossoms came. Of course many blossoms were in full bloom on this date. It is thought that

some relationship exists between this injury and the russet banding of apples and pears observed in this section in 1895, which was undoubtedly due to frost injury aggravated by dew freezing on the fruit, as is set forth in the ninth report of this Station; that, in other words, each of these troubles was due to a frost injury, the results being differently manifested. It is further thought that the so-called "fruit pit" and "corky core," likewise apparently due to weather conditions, resemble this gnarly fruit malady, the differences being those of degree only.

No effectual remedy has been suggested as against physiological diseases of this character.

THE THERMAL DEATH POINT IN YEAST

BY E. P. WELLS

Theoretically both the housewife and the baker could bake a more wholesome and uniform loaf and those who eat bread would be less likely to seed their alimentary canal with living yeasts, if yeast thermal death points were known. Little information seems to be at hand, however, except in relation to the brewing industry, and this seems contradictory. Figures are given by various writers as to death points varying all the way from 40 to 105° in the cell form and from 65 to 120° C in the spore form.

The definition of the Society of American Bacteriologists to the effect that the thermal death point of an organism is the lowest temperature which will kill it in ten minutes was adopted in this study. All the work was done with *Saccharomyces cerevisiae*. The interesting fact was brought out by this work that the thermal death point of this yeast was not always the same. The addition either of sugars or colloids, such as starch, raised it as will be seen from the following results. This increase was not, however, sufficient to prevent the destruction of the yeasts in bread that was thoroughly baked. Loaves that had been baked sufficiently to show a well browned crust did not contain living yeast cells.

TEMPERATURE TRIALS

In synthetic broth (water 1,000, dextrose 100, peptone 20, ammonium nitrate 10, potassium nitrate 5, magnesium sulphate and acid

potassium phosphate, each 2.5, calcium chlorid, 1; reaction N/10 sodium hydroxid and phenolphthalein, 75) 60° C.

In synthetic broth (diluted; 3 broth, 1 water) 58° C.

In synthetic broth (concentrated; 5 gr. dextrose, 15 cc. broth) 62° C.

In thin batter (15 gr. flour, 45 cc. water) 66° C.

In medium batter (15 gr. flour, 15 cc. water) 84° C.

In thick batter (45 gr. flour, 15 cc. water) 100° C.

These last two results seem abnormally high and need confirmation.

In bread (2 pints flour, 2 cups boiled water, 1 tablespoonful sugar, 2 cakes Fleischmann's yeast dissolved in ¼ cup lukewarm water). Two sets of bread were made. The first set was less perfectly controlled than it should have been as to rise of temperature within the loaf after it had been removed from the oven, a point which seems to have been overlooked or disregarded by previous workers who have deemed 61° to 65° C, a temperature sufficient to kill yeast in bread. In this first set of 20 trials, yeast was found present three times in loaves baked at 65° F. and twice it was not found. It was not found at all in loaves which registered 68° C or more within the loaf. In the second and more carefully conducted set, with the closest possible control so that no "after rise" in temperature occurred, living yeast cells were uniformly found in bread baked at a temperature of 66° C or less and in no case were they found in loaves baked at 68° C.

It seems safe to say that the thermal death point of yeast in bread making approximates 68° C.

SOIL STERILIZATION

By F. O. Ockerblad, Jr.

Soil sterilization is becoming a somewhat common greenhouse practice and is sometimes done in the open field. Steam and chemicals are commonly used. To be serviceable the sterilizing agency must be effective, inexpensive, readily applied and leave no injurious products in the soil. Steam, phenol, sulphuric acid, formaldehyde (formalin), carbon disulphid and pyridene were used in the trials cited in this thesis. The steaming was done in an autoclave, glass tubes 1 inch wide and 12 inches long and 8-inch flower pots (3 kilo soil capacity) of greenhouse soil being used, the steam being applied once for either one, two or

five hours and for half-hours on three successive days. The soil contained approximately 3,250,000 organisms per cubic centimeter. The chemicals were used in 0.1, 0.5 and one percent solutions applied at the rate of one liter per square foot. Plating was done on plain agar by the usual dilution method and plates were incubated at room temperature for a week. The salient results were as follows:

EFFECT OF STEAM STERILIZATION IN 12-INCH GLASS TUBES OF SOIL

Time applied	Soil depth	Percentage killed
1 hour	Surface	99.7
1 "	2.5 centimeters	98.9
1 "	5 "	98.4
1 "	10 "	97.3
1 "	20 "	8.1
1 "	30 "	21.1
2 hours	Surface	99.9
2 "	2.5 centimeters	99.9
2 "	5 "	99.9
2 "	10 "	94.7
2 "	20 "	94.7
2 "	30 "	90.8
5 hours	Surface	99.99
5 "	2.5 centimeters	99.99
5 "	5 "	99.99
5 "	10 "	99.99
5 "	20 "	99.99
5 "	30 "	99.79
½ hour, 3 days	Surface	99.99
½ " 3 "	2.5 centimeters	99.7
½ " 3 "	5 "	99.8
½ " 3 "	10 "	99.8
½ " 3 "	20 "	99.8
½ " 3 "	30 "	89.3

EFFECT OF STEAM STERILIZATION IN 8-INCH POTS

1 hour	Surface	99.7
1 "	Center	99.3
1 "	Bottom	99.4
½ hour, 3 days	Surface	99.9
½ " 3 "	Center	97.2
½ " 3 "	Bottom	97.9

Little difference was observed in the surface soil as between the several treatments. At a depth of 30 centimeters (approximately one foot) wide differences occurred. The five-hour steaming treatment proved most effective at all depths. The high percentage of organisms killed at depths of 20 and 30 centimeters was not anticipated. It is an open question whether this was not due to the penetration of the dry heat through the walls of the glass tube. The likelihood that equally good results would be secured in actual practice is not great.

Oats were grown in pots of steamed and unsteamed soil, dry matter production being approximately one-seventh greater on the treated soil.

The chemicals were used in solutions of 0.1, 0.5 and one percent strength, save formaldehyde which was used in 0.4, 0.8 and 1.2 percent solutions. They were applied to greenhouse beds five inches deep. The plots were covered for a day or two before being aired. The results of the one and two days exposures were as follows:

Phenol: Nil; doubtless due to soil combinations formed with sulphates.

Carbon disulphid: Almost nil, varying from no result in three cases to one-third killed in one case, the variations probably being due to vaporization.

Pyridine: Results discordant; apparently somewhat effective at 0.1 percent strength (72.5, 87.2 percents) and less so at greater concentration, although two days' exposure at 0.2 percent killed 93 percent of the organisms.

Sulphuric acid: Fairly effective and, paradoxically, the more so the less was used and the less the time of exposure. A one-day exposure accounted for 96.7, 91.3 and 92.6 percents of the organisms; two-day exposures for 68.3, 86.9 and 77.6 percents. This is probably due to combinations formed with soil salts.

Formaldehyde: Most effective of all the materials tried, since in four of the six trials more than 99 percent of the organisms were killed and in the fifth 97.2 percent were killed. In the sixth case the results were inconclusive. The gas seems to combine with, or in some way to affect, the albuminous contents of the bacterial cell, thus inhibiting reproduction.

Steam proved more effective than any chemical, but was found to be cumbersome to use and to be limited in range of action. Formaldehyde, which proved the most effective chemical agent, cost about one and one-half cents per square yard of application.

Samples of soil were taken from plots to which air slaked and quick limes, as well as chlorid of lime, had been applied at the rate of 150 bushels per acre, representing depths near the surface, from three to six inches, and from six to nine inches. The surface of the limed plots carried from 36 to 60 percent less microorganisms than did the check plots, but at the other two depths the bacterial population was much larger, the increase ranging from 51 to 498 percent.

THE COST OF PRODUCING MAPLE PRODUCTS IN 1912 AND 1913

BY C. J. FRINK

Sugar making is usually thought to be a profitable line of work. It may be such, yet it may be simply a means of selling one's labor to one's self at a time of year when it is more or less of a drug on the market and of selling otherwise unsaleable woodlot odds and ends to one's self for firewood. If sugarmakers figured the proposition in the same manner that makers of butter in a creamery, or of scales in the Fairbanks or Howe shops, or of textiles in Bennington or Winooski mills study their business affairs; if they calculated and allowed for all the expenses incident to the operation of the sugar plant, it is doubtful whether the outcome in all cases would be found to be a satisfactory one.

Fairly full data were secured as to the operations during the season of 1912 of 52 representative sugar makers in Franklin, Lamoille, Orleans and Orange Counties, and as to the operations during the season of 1913 of nine operators, included among those interrogated during the preceding year, men who kept fairly accurate records of their 1913 labor charges and exactly accurate records as to their 1913 production. Personal interviews were sought in each case and the replies received were subjected to careful scrutiny and analysis. Of course the data are not accurate in the absolute sense of the word, but they are thought to be sufficiently correct to enable one to draw deductions which will not be found to be very wide of the mark. It should be remarked, however, that the season of 1912 was barely an average one, the mean production per tree being 1.9 pounds.

The figures secured show for each producer: production (sugar, syrup, and calculated to the sugar basis); value (per unit, total); equipment (in detail, value of each item, total investment); labor, men and team (days, values, totals); wood (cords, value, totals); use of sled; interest and depreciation; cost of packages; total cost of production; profit or loss; cost per unit of production (sugar, syrup); total cost less cost of package and man labor; value of man-labor per day; profit or loss per one dollar cost; investment per bucket; production per bucket; total cost per bucket.

The following table sets forth maxima, minima and average figures: the three columns to the left representing the 1912 data, the three to the right the 1913 data:

	1912 data; 52 producers			1913 data; 9 producers		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Production (calculated as sugar) lbs.	3000	400	1477	4150	836	1756
Value of product per unit						
Sugar, per pound, cents	16	9	11.1	17	8.8	13.2
Syrup, per gallon	$ 1.25	$ 0.75	$ 0.94	$ 1.25	$ 0.90	$ 1.10
Total value of entire production	337.50	42.75	169.55	508.38	125.75	231.70
Equipment; total investment	988.00	157.50	479.16	970.50	334.50	563.98
Labor: Man	103.00	16.10	53.13	128.51	40.25	65.70
Team	48.00	9.00	27.60	55.20	5.00	29.34
Total	144.60	19.32	80.73	183.71	45.25	95.04
Wood: Cords	20	4	11	25	5	12.5
Value per cord	$ 4.00	$ 1.50	$ 2.28	$ 4.00	$ 1.00	$ 2.17
Total	64.00	8.00	25.08	100.00	12.50	29.60
Interest	59.28	9.05	28.75	58.23	20.07	34.49
Depreciation	41.16	7.16	20.52	42.88	14.98	24.93
Package costs	26.00	1.60	9.86	20.56	5.20	12.19
Total costs	275.92	47.93	163.90	406.07	110.05	193.38
Profits*	123.82	2.07	41.62	118.75	15.40	60.22
Losses*	72.10	6.61	32.51	64.18	1.63	32.90
Profit and loss	123.82	—72.10	5.98	118.75	—64.18	39.52
Cost per unit						
Sugar, per pound, cents	18.1	6	11.	15.7	8.1	10.8
Syrup, per gallon	$ 1.45	$ 0.49	$ 0.86	$ 1.26	$ 0.65	$ 0.86
Cost less package and man-labor charges	213.86	24.61	97.33	263.06	63.30	116.19
Value of man-labor per day	5.32	0.66	1.95	4.64	0.21	2.55
Profit per one dollar of cost*, cents	70	1	23	76	15	34
Loss per one dollar of cost*, cents	52	5	22	29	1	15
Profit and loss per one dollar of cost, cents	70	—52	1	76	—29	23
Investment per bucket	$ 1.04	$ 0.45	$ 0.63	$ 0.83	$ 0.39	$ 0.62
Production per bucket, lbs.	3.4	1.0	1.9	2.8	0.9	1.87
Total cost per bucket, cents	32	11	21	26	11	21

*Profits in 27 orchards in 1912 and 7 in 1913; losses in 25 orchards in 1912 and 1 in 1913.

It will be observed that in a general way the more accurate data secured in 1913 from the smaller number who kept strict account of their operations bear out the results secured in 1912 from the larger number of sugar makers whose operations were less closely controlled and the accuracy of whose figures is not as free from question.

The prices at which the 1913 products sold were on the whole higher than those secured in 1912 and the orchards averaged to be somewhat larger than were those used in the 1912 study, a difference which may have affected cross comparisons; but, bearing this fact in mind, one finds on the whole a fair degree of concordance.

Graphs I to VIII graphically set forth the salient features of this study. They deal with only the 1912 data, the general correctness of which is fairly well attested by the comparisons shown above.

	Minimum	Maximum	Average
(a) Number of sap buckets	170	1800	744
(b) Investment	$157.50	$988.00	$479.16
(c) Production per bucket.....	1 lb.	3.4 lbs.	1.9 lbs.
(d) Total production	400 lbs.	3000 lbs.	1477 lbs.

Eight of the ten curves indicate in relation to the number of sap buckets in use (a factor which is generally conceded to be the most accurate measure of the size of the sugaring plant):

(1) The total investment (Graph I).

(2) The number of days of man-labor (Graph II).

(3) The number of days of horse-labor (Graph III).

(4) The total cost less that of the package (Graph IV).

(5) The total cost less that of man-labor (Graph V).

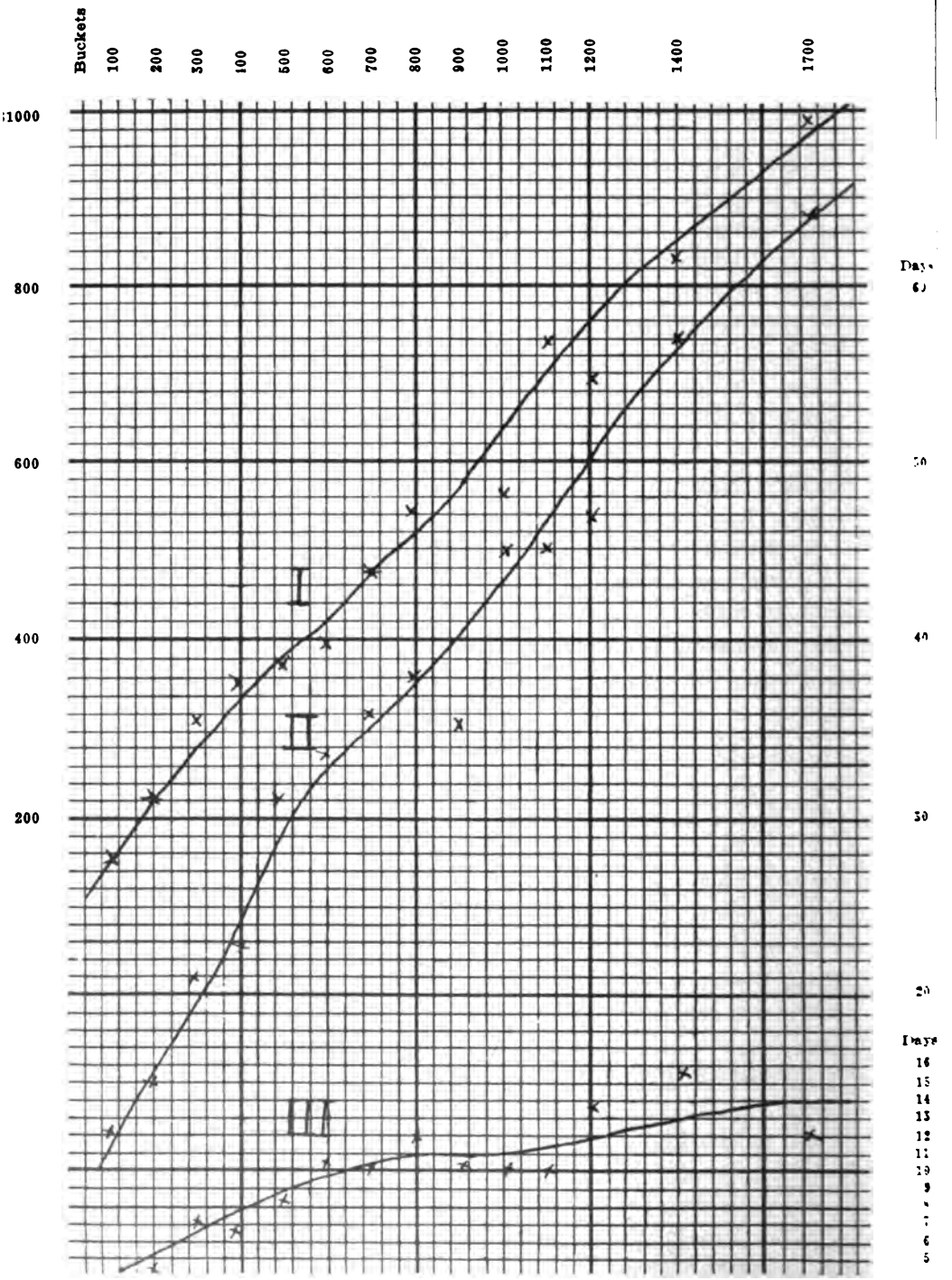
(6) Cost per pound of sugar less that of the package (Graph VI).

(7) Total cost (less package) per bucket (Graph VII).

(8) Investment per bucket (Graph VIII).

In order to plot these data the producers of 1912, 52 in number, were grouped on the basis of their bucket usage. But three used more than 1,300 buckets. The figures corresponding to these results were derived by averaging the investments, etc., etc., of the producers in each group. The data on which these curves are predicated are as follows:

Number of buckets	Number of producers	Total investment	Man-labor, days	Horse-labor, days	Cost per pound less package	Total cost per bucket less package	Total cost less package	Total cost less package and man labor	Investment per bucket
		$	days	days	cts.	cts.	$	$	cts.
100- 200	1	157.50	12.	...	11.	0.21	43.93	24.61	0.81
200- 300	2	218.65	15.	4.5	14.5	0.25	61.83	37.68	0.85
300- 400	3	310.50	20.7	7.	13.4	0.29	111.06	77.78	0.80
400- 500	9	350.62	22.7	6.6	10.8	0.22	108.70	70.10	0.71
500- 600	5	370.60	30.8	8.2	16.1	0.23	134.50	83.12	0.64
600- 700	5	394.20	33.5	10.5	10.1	0.22	156.06	102.13	0.56
700- 800	7	479.39	35.8	10.1	11.1	0.21	166.13	108.45	0.66
800- 900	3	553.80	38.	12.	9.8	0.21	177.46	116.25	0.60
900-1000	9	580.54	35.	10.3	10.4	0.17	173.12	118.00	0.59
1000-1100	1	568.15	45.	10.	6.9	0.18	185.92	113.47	0.55
1100-1200	3	735.50	45.	10.	8.8	0.17	205.80	133.50	0.61
1200-1300	2	695.57	47.	13.5	10.4	0.17	220.62	145.85	0.51
1400-1500	2	834.62	57.	15.5	10.1	0.17	274.62	177.87	0.52
1700-1800	1	988.00	64.	12.	8.6	0.15	260.92	157.92	0.52
Graph reference		I	II	III	IV	V	VI	VII	VIII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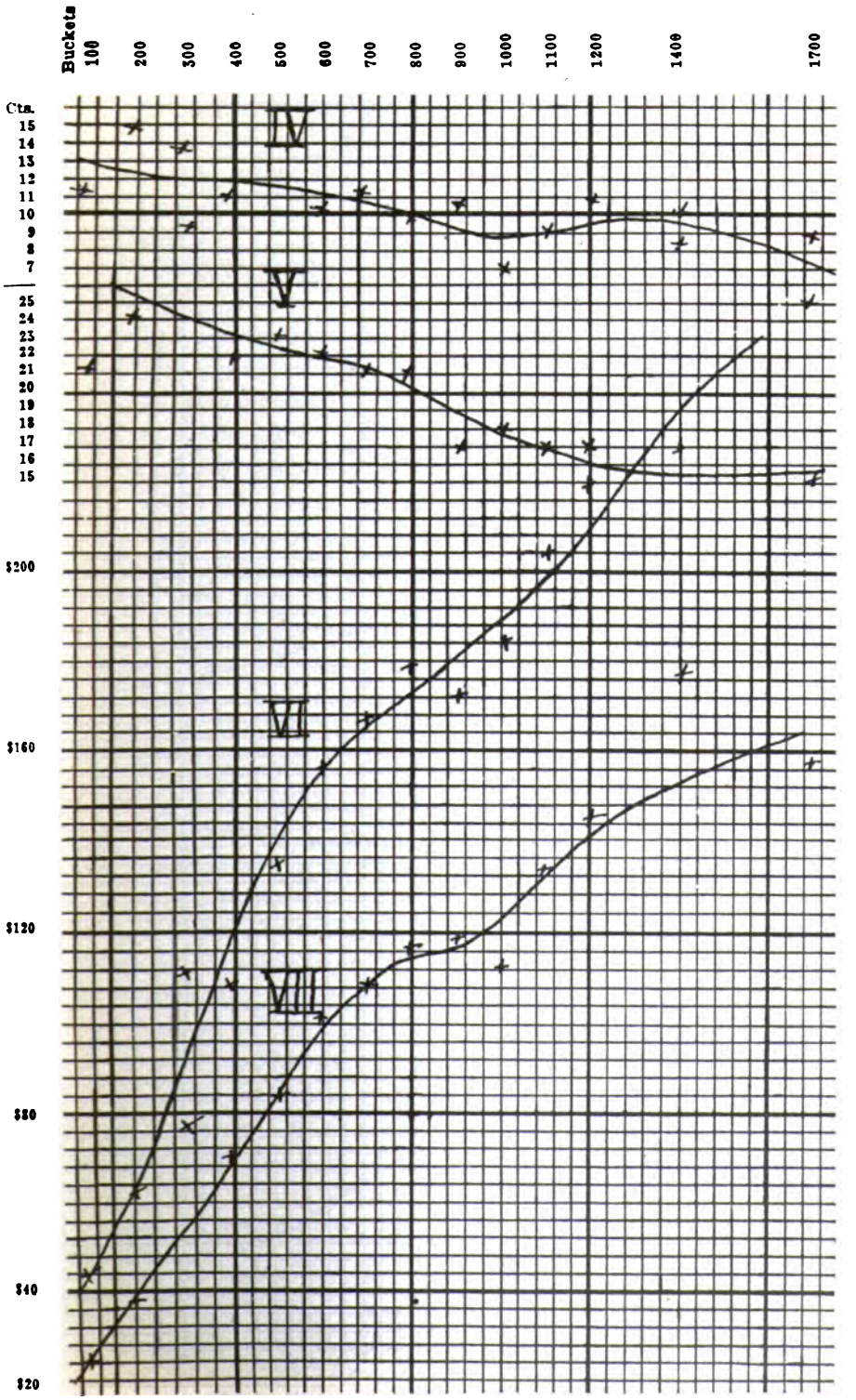
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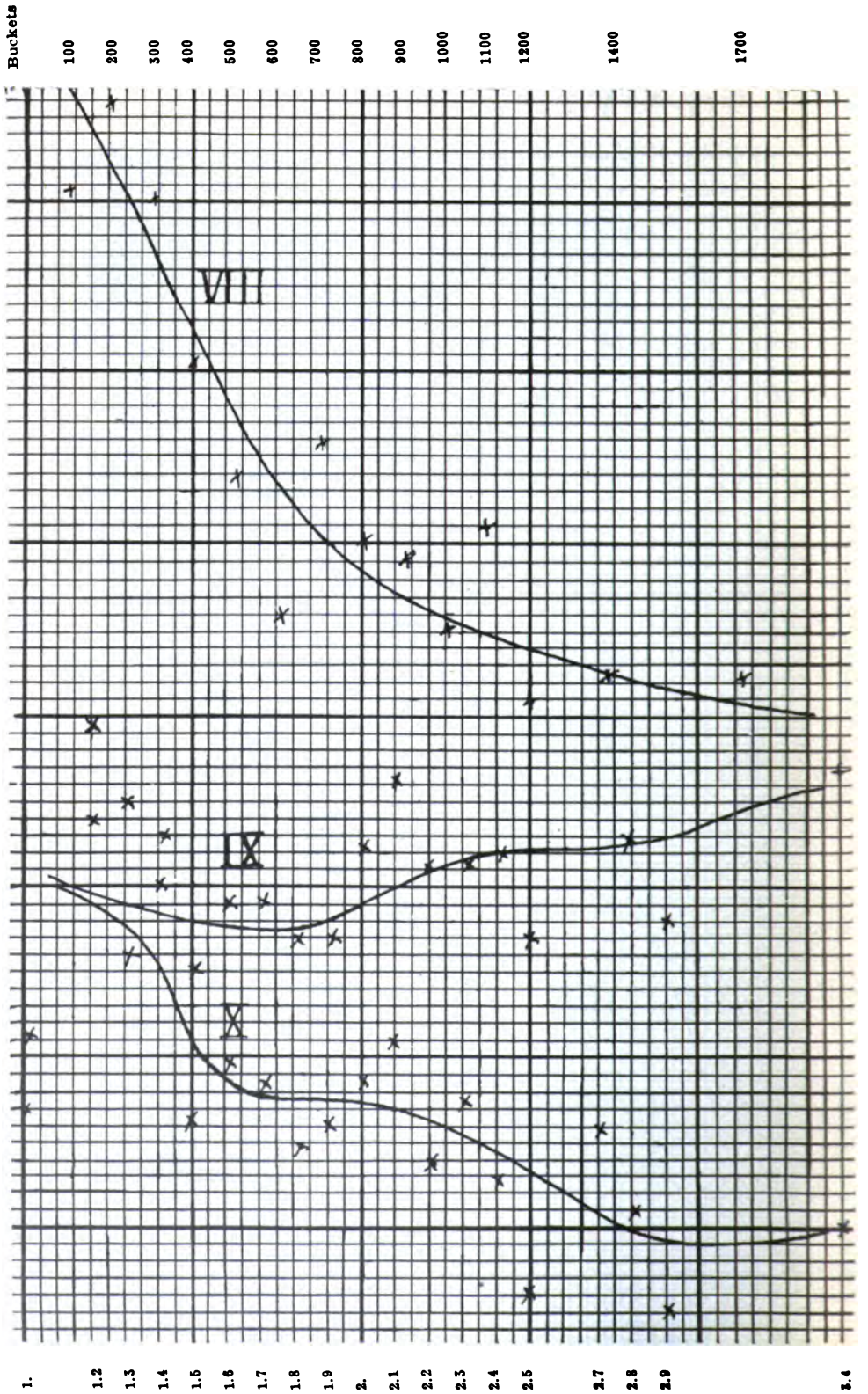
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2.5
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3.4
Production per buckets, lbs.

Concerning these graphs it may be said:

1. *Relation of investment to size of orchard* (Graph I). Clearly as the size of the orchard increases, the investment increases. In mathematical terms the curve almost exactly bisects the angle between the ordinate and the abscissa. And this, theoretically, is about what it ought to do.

2. *Relation of labor to size of orchard* (Graphs II and III). Three things appear:

(a) The number of days of man-labor increases rapidly.

(b) The amount of horse-labor does not increase to any marked extent coincident with the increase in the size of the orchard.

(c) As a corollary of the last observation it would appear that as the size of the orchard increases the labor cost per bucket decreases.

3. *Relation of cost to size of orchard* (Graphs IV and V). Clearly the cost of making a unit of product per bucket and the total cost of operation of a bucket—the package costs being eliminated—tend to decrease with the increase in the size of the plant, and, moreover, the curves are fairly parallel. In this connection it is significant to note that two-thirds of the 27 orchards which made a profit hung 800 or more buckets, whereas in more than two-thirds of the 25 orchards wherein no profit was made less than 800 buckets were hung. It is the old story of the relationship of the size of the business to its success, applied to a special line of work. A profit was made in only three sugar bushes in which less than 500 buckets were hung.

4. *Relation of cost to size of orchard* (Graphs VI, VII). The total cost of production (less package cost) is a factor of the size of the business as appears by the curve. When, however, the man labor item is eliminated the increase in cost is less rapid after than it is before the 500 bucket limit is passed.

5. *Relation of investment per bucket to size of orchard* (Graph VIII). The curve which sets forth the results obtained in this comparison is the reverse of those hitherto exhibited. The investment per bucket decreases rapidly in the smaller orchards, and less rapidly in the larger ones, but the trend is always downwards, the cost being relatively less as the size of the operation increases.

Graphs IX and X show:

1. The relation of the total cost per bucket to the production per bucket. (Graph IX).

2. The relation of the cost per pound of product to the production per bucket. (Graph X).

These data are set forth numerically as follows:

Production per bucket, pounds	Number of producers	Total cost per bucket	Cost per pound	Production per bucket, pounds	Number of producers	Total cost per bucket	Cost per pound
		cts.	cts.			cts.	cts.
1.	1	11	10.8	2.	6	22	11.5
1.2	2	24	19.7	2.1	3	26	12.4
1.3	5	25	14.4	2.2	3	21	9.5
1.4	3	23	16.	2.3	1	21	11.
1.5	2	15	10.6	2.4	2	22	9.1
1.6	6	19	11.9	2.5	2	17	6.5
1.7	2	19	11.5	2.7	1	28	10.3
1.8	3	17	10.	2.8	3	23	8.3
1.9	6	17	10.5	2.9	1	18	6.
				3.4	1	27	8.
Graph reference		IX	X			IX	X

1. *Relation of total cost per bucket to production per bucket* (Graph IX). This curve gets nowhere. There are wide divergences in the results which scatter like shrapnel. There seems to be no general tendency for the total cost per bucket to increase with the increase in production per bucket.

2. *Relation of total cost per pound to production per bucket* (Graph X). This is a significant curve. The decrease in the cost per pound which coincides with the increased yield per bucket is due to the fact that it costs nearly, although not quite, as much to handle a small as it does to handle a large run of sap. Hence the larger the flow, the cheaper a unit of product may be made.

This curve, and the table upon which it is based, may well serve a good purpose in enabling a producer to arrive at some general idea as to the probable cost of a pound of sugar for any given average bucket production. Assume, for example, that a three-pound per bucket yield has been secured under the average conditions obtaining in the trials now under survey with a medium size orchard. It would be safe to say that under such conditions it costs fully 7.5 cents to make a pound of sugar before it is put into the package, and, of course, proportionately more with smaller yields. With this information in hand one can the better determine whether to make sugar or syrup, the type of package to use, and the price at which it will be necessary to sell it in order to make a profit.

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FEEDING STUFFS

By J. L. HILLS, C. H. JONES and G. F. ANDERSON

CONCERNING ALFALFA AND SOY BEANS

By J. L. HILLS

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BULLETIN 204: COMMERCIAL FEEDING STUFFS

By J. L. Hills, C. H. Jones and G. F. Anderson

CONCERNING ALFALFA AND SOY BEANS

By J. L. Hills

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I. SUMMARY

Nearly 600 samples representing about 350 different brands of feeding stuffs were analyzed in the 1917 inspection. The results were not very encouraging. They may be summarized as follows:

If we may judge of the entire trade by the samples drawn by the Station—and there is no other criterion by which to judge—

1. Nearly two-thirds of the cottonseed meals sold last winter in Vermont were not what they were represented to be in respect to their protein contents.

2. Nearly two-fifths of the distillers' dried grains was similarly deficient.

3. One out of ten of the wheat feeds was similarly deficient.

4. One out of six proprietary stock and poultry feeds was similarly deficient.

In view of the fact that last year's inspection showed a bad state of affairs it is not much to say that, speaking broadly, Vermonters during the past two years have been paying more for poorer goods than at any time during the last twenty years.

What can they do about it? Little or nothing except to watch the bulletin statements and do what they can to buy brands which seem likely—in view of their past history—to be as good as they are said to be, provided their promises are adequate. It would, of course, be farcical to buy a low grade goods at a high price because the guaranty was maintained instead of a high graded brand at a medium or, indeed, high price because it was not quite as good as it was said to be. In other words, guaranty maintenance is but one of several factors which should be borne in mind in determining the choice of feed. However, as between two brands of the same class and same guarantied protein content, other things being equal, farmers would do well to buy the brand whose record is lily-white rather than one whose past history is blemished by exaggerated guaranty claims. The statements on pages 14 to 34, alphabetically arranged by manufacturers' or jobbers' names within classes, will enable anyone readily to determine the facts concerning any feeding stuff as developed in the past season's inspection.

II. INTRODUCTION

The sampling agents of the Station visited 28 cities, towns and villages in Vermont in late December, 1916, and early January, 1917, and drew 611 samples from dealers' stocks, representing nearly 350 brands of goods which either are subject to or exempt from the necessity of guaranty. Several of the larger wholesale and many retail places were visited, but points remote from the railroad were not reached. The appropriation for this particular line of work—five hundred dollars a year—is so small that it is and always has been impossible to cover the field properly or to make an adequate inspection. All of these samples were examined chemically for protein only, for the reason indicated in the preceding sentence. No attempt has been made to determine whether or not manufacturers' statements as to ingredients were not truthful.

The reader who may be interested in the economics of feed purchase is referred to matter on pages 34 to 44 of bulletin 144, as well as to that on pages 582 to 590 of bulletin 152. Full descriptions of the nature and manufacture of the various goods offered on the Vermont market will be found on pages 22 to 34 of bulletin 144, together with a discussion of the advisability or inadvisability of their purchase, as the matter appealed to the writer when the bulletin was written.

SYNOPSIS OF THE PUBLIC STATUTES DEALING WITH FEEDING STUFFS

The essentials of the Vermont feeding stuff law are as follows:

Sections 4983-4. *Definition of the term "concentrated commercial feeding stuff";* including the common feeds other than hay, straw, whole seeds and unmixed meals, wheat, rye and buckwheat offals.

Section 4985. *Statement of contents;* net weight, brand name and address of manufacturer, minimum percentages of crude protein and crude fat, maximum percentage of crude fiber, and the specific name of each ingredient used in manufacture.

Section 4986. *Illegal sales; penalty.* The omission of the guaranty, a material overstatement of the actual protein or fat contents or understatement of the actual fiber contents, and the omission of or incorrect statement of the specific name of each ingredient are forbidden; fine, not to exceed fifty dollars for the first or one hundred dollars for each subsequent offense.

Section 4987. *Adulterations; exceptions; penalty.* The adulteration of whole or ground grain, or of bran, middlings or mixed

feed with offals, unless the fact is stated on each package, and the inclusion of more than two percent by weight of weed seeds unless stated on each package, are forbidden; fine, not less than twenty-five dollars nor more than one hundred dollars.

Section 4988. *Appropriation; expenses; report.* Five hundred dollars annual appropriation; annual financial statement to be published by the Station.

Section 4989. *Prosecutions.* Notice to dealer giving thirty days time wherein to comply with law; failing which, report is made to state's attorney; no prosecution in relation to quality if the same is substantially equivalent to the guaranty.

Section 4990. *Collection of samples.* Authorization to enter and take samples; not less than five percent of entire lot to be sampled, thoroughly mixed, sealed and labelled; samples to be taken in duplicate if requested by the dealer.

Section 4991. *Analyses of samples; publication.* One sample of each brand to be analyzed; results, together with additional information in relation to the character, composition, value and use of feeding stuffs, shall be published.

Section 4992. *Exception.* Act does not apply to persons purchasing feeding stuffs for their own use and not for sale.

Section 4993. *Obstructing director; penalty.* Provision against hindrance in execution of law.

On the whole the law is fairly well observed at present. In a few cases, particularly when mixtures are locally made in a small way by Vermont dealers, the packages do not declare their contents in terms of ingredients as is now required by law. Unguaranteed goods are infrequent at the present time and overguaranties are not as common as once they were; but overstatements in advertising still occur. The law cannot control extravagant statements in the press or elsewhere. It is for the buyers to look askance thereat and to ask the Station as to the facts.

It is not generally appreciated that there is a federal law which aids in preventing misbranding, misstatement and adulteration of such goods as may enter into interstate commerce. The state law, of course, cannot hold outside of state lines; but serious cases of fraud may be reported to federal authorities. In this way local dealers who sell in good faith need not be troubled to any great extent and the parties actually responsible for illegal sales may be reached.

The revised method of statement of analytical results employed in bulletin 197 and explained at length on pages 8 to 10 of that publication has been continued in this issue.

The new method shows: The name and address of the manufacturer; of the local dealer or dealers from whose stocks the samples were drawn; the brand name; the "specific name of each ingredient used in (the) manufacture" of the feeding stuff, in case it is a compounded material, as stated by the manufacturer upon bag or tag; the percentage of crude protein guaranteed by the manufacturer to be present; the accuracy of the manufacturer's protein guaranty, stated not in terms of figures but in terms of words—using the phrase "guaranty fulfilled" if as a matter of fact the goods contained as much protein as they were said to contain, or the phrase "but failed by—percent to fulfill guaranty" if as a matter of fact the goods did not contain as much crude protein as they were said to contain.

Within classes, the order of arrangement is alphabetical by manufacturers' names, which are printed in small capitals; brand names and guaranties are printed in italics.

This system groups within a single paragraph all the information which the Station is able to purvey concerning a given sample. Not all that might be given to advantage, not all that is usually given in the feeding stuffs inspection bulletins of other States, but all that can be furnished in view of the meagre appropriation.

Concerning the phraseology in the tabular matter in cases where guaranties are not made good, it should be said that wherever the shortage was but a fraction of a percent, no stress should be laid upon it, unless the crude protein guaranty is a low one, say 12 percent or less. Of course a one-half percent deficiency in a goods guarantied to contain but 10 percent protein is equivalent to a 5 percent shortage, whereas a similar lack in a cottonseed meal, guarantied to carry 41 percent, would amount to but little more than 1 percent of the promised amount.

Concerning the phraseology used by some manufacturers in naming the "specific ingredients," it may be said that the Standard Dictionary defines an "ingredient" to be "that which is placed in or specifically enters into the constitution of any mixture or compound, or is a component part of any conglomerate; component; part; as, the ingredients of gunpowder are niter, charcoal and sulphur." Now "oat feed," for example, is not an ingredient, but a combination of ingredients, just as gunpowder is not an ingredient but a combination of ingredients; hence

labels carrying such statements are held by all feeding stuff control officials to be "illegal" and are so designated in the tabular matter.

The attention of the writer has been called to the fact that he has erred in stating in previous bulletins that "clipped oat by-product," as now interpreted by the Association of Official Feed Analysts, is not an ingredient but a combination of ingredients, and that labels which use this phraseology are "illegal." He regrets his error.

STANDARDS: AVERAGE COMPOSITION

A standard is defined to be "a measure of quality established by law or by general usage or consent; any type, model, example or authority with which comparison may be made; any fact, thing or circumstance forming a basis for adjustment and regulation." Now standards, i. e., "measures of quality," "examples with which comparison may be made," are of service in connection with the use of feeding stuffs. Thus one is able the better to pass judgment on the worth of a given sample. The percentages of protein, fat and fiber form in part the basis of judgment in this connection. If a given sample is of good appearance, neither moldy, rancid nor in other ways spoiled, is mechanically in good condition, is free from objectionable foreign matter and carries approximately the protein and fat percentages and not materially more than the fiber content shown below, it is probably safe to assume it to be of standard quality.

The following table of averages indicates closely the average composition of the goods more commonly sold in Vermont.

I. GOODS CARRYING MORE THAN 30 PERCENT PROTEIN

	Protein	Fat	Fiber
Cottonseed meal (choice)	41.	9.5	7.
Cottonseed meal (prime and good)	36.	8.	8.
Linseed meal (new process)	36.8	2.8	9.
Linseed meal (old process)	34.1	7.6	9.
Distillers' dried grains (first grade)	31.6	13.1	12.

II. GOODS CARRYING 25 TO 30 PERCENT PROTEIN

Buckwheat middlings	29.1	7.5	5.
Distillers' dried grains (second grade)	27.5	11.5	13.
Brewers' dried grains	26.1	7.1	12.
Malt sprouts	26.5	1.5	12.5

III. GOODS CARRYING 20 TO 25 PERCENT PROTEIN

Gluten feeds	23.7	3.	7.5

IV. GOODS CARRYING 15 TO 20 PERCENT PROTEIN

	Protein	Fat	Fiber
Molasses feeds (as a class) exclusive of horse feeds	16.2	3.4	12.
Wheat middlings	17.1	5.1	5.
Wheat mixed feed	16.2	4.8	9.
Wheat bran	15.2	4.7	10.

V. GOODS CARRYING 10 TO 15 PERCENT PROTEIN

Molasses feeds for horses (as a class)	12.4	3.3	15.
Fortified oat feeds	12.9	3.8	8.
Alfalfa meals	13.1	1.3	28.
Hominy meal	10.5	8.4	4.5
Ground oats	10.6	4.8	10.

VI. GOODS CARRYING 5 TO 10 PERCENT PROTEIN

Corn and oat feeds (as a class)	9.2	4.3	6.
Provender	9.2	4.3	6.
Oat feeds (as a class)	6.8	3.1	20.
Corn meal	8.9	3.4	2.
Dried beet pulp	8.	0.3	18.

VII. POULTRY FEEDS

Meat scraps	50.	10.	..
Meat and bone meals	40.	10.	..
Mashes	16.	4.	7.
Chick feed	12.	3.	3.
Scratch feed	11.	3.	3.

DEFINITIONS OF FEEDING STUFFS AND "INGREDIENTS"

The feeding stuffs law, as amended by the General Assembly of 1912, requires a statement of "the specific name of each ingredient used in its manufacture" on "each lot or parcel of concentrated commercial feeding stuff." Manufacturers have not in all cases complied with this feature of the law.

Cottonseed meals, linseed meals, gluten feeds, distillers' dried grains, brewers' dried grains, malt sprouts, dried beet pulp, hominy feed, ground beef or fish scraps, all of them "concentrated commercial feeding stuffs" as defined in Section 4983 P. S., if true to name and not sold under some trade name not indicative of their true nature, are not held to be compounded materials and, hence, no special statement as to "ingredients" need appear on the package.

Cottonseed feeds, molasses feeds, oat feeds, corn and oat feeds, proprietary mixtures and mixed feeds (not wheat mixed feeds free from adulteration or from wheat screenings), condimental stock and poultry foods, and stock feeds, must carry on each package a statement of their ingredients. Lack of funds prevents any careful survey of the samples to determine whether or not as a matter of fact the statements of ingredients made by the manufacturer are accurate. On account of its lack of information the Station expresses no opinion as to whether in any given case manufacturers' statements in this respect are or are not reliable. However, it knows of no reason to allege inaccuracy in any case. The manufacturers' statements occur on pages 14 to 34.

DEFINITIONS OF FEEDING STUFFS ADOPTED BY THE ASSOCIATION OF FEED CONTROL OFFICIALS OF THE UNITED STATES NOV. 17-18, 1911, NOV. 18-19, 1912, NOV. 17-18, 1913, NOV. 13-14, 1914, NOV. 18-19, 1915 NOV. 17-18, 1916

Meal is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent.

Chop is a ground or chopped feed composed of one or more different cereals or by-products thereof. If it bears a name descriptive of the kind of cereals, it must be made exclusively of the entire grains of those cereals.

Screenings are the smaller, imperfect grains, weed seeds and other foreign material having feeding value, separated in cleaning the grain.

Alfalfa meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

ANIMAL PRODUCTS

Blood meal is ground dried blood.

Cracklings are the residue after partially extracting the fats and oils from the animal tissue. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

BREWERS' AND DISTILLERS' PRODUCTS

Brewers' dried grains are the properly dried residue from cereals obtained in the manufacture of beer.

Distillers' dried grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation indicating the cereal predominating.

Malt sprouts are the sprouts of the barley grain. If the sprouts are derived from any other malted cereal, the source must be designated.

BUCKWHEAT PRODUCTS

Buckwheat shorts or buckwheat middlings are that portion of the buckwheat grain immediately inside of the hull after separation from the flour.

CORN PRODUCTS

Corn bran is the outer coating of the corn kernel.

Corn germ meal is a product in the manufacture of starch, glucose and other corn products, and is the germ layer from which a part of the corn oil has been extracted.

Grits are the hard, flinty portions of Indian corn, without hulls and germs.

Hominy meal, hominy feed or hominy chop is a mixture of the bran coating, the germ and a part of the starchy portion of the corn kernel obtained in the manufacture of hominy grits for human consumption.

Corn gluten meal is that part of commercial shelled corn that remains after the separation of the larger part of the starch, the germ and the bran, by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

Corn gluten feed is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

OIL CAKE

Oil cake is the residual cake obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure for seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "oil cake" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product, the name of the seed from which it is obtained shall be prefixed to "oil cake."

Ground oil cake is the product obtained by grinding oil cake. When used alone, the term "ground oil cake" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "ground oil cake."

COTTONSEED PRODUCTS

Cottonseed meal is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 percent of protein.

Choice cottonseed meal must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and must contain at least 41 percent of protein.

Prime cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 percent of protein.

Good cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 percent of protein.

Cottonseed feed is a mixture of cottonseed meal and cottonseed hulls, containing less than 36 percent of protein.

Cold pressed cottonseed is the product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire cottonseed less the oil extracted.

Ground cold pressed cottonseed is the ground product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire ground cottonseed less the oil extracted.

LINSEED AND FLAX PRODUCTS

Flax plant by-product is that portion of the flax plant remaining after the separation of the seed, the bast fiber and a portion of the shives, and consists of flax shives, flax pods, broken and immature flax seeds and the cortical tissue of the stem.

Linseed meal is the ground product obtained after extraction of part of the oil from ground flaxseed screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes.

Oil meal is the ground product obtained after the extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from seeds which have been screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "oil meal" shall be understood to designate the product obtained from screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to the words "oil meal."

Old process oil meal is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "old process oil meal" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "old process oil meal."

New process oil meal is the ground product obtained after extraction of part of the oil by crushing, heating and the use of solvents from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "new process oil meal" shall be understood to designate the product obtained from partially extracted screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "new process oil meal."

Unscreened flaxseed oil feed is the ground product obtained after extraction of part of the oil from unscreened flaxseed by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents. When sold without grinding the unground product shall be designated as "unscreened flaxseed oil feed cake."

Ingredients of unscreened flaxseed oil feed—Ground cake from partially extracted flaxseed and foreign seeds (wheat, wild buckwheat, pigeon grass, wild mustard, etc.).

Screenings oil feed is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from the smaller imperfect grains, weed seeds and other foreign materials having feeding value separated in cleaning the grain. The name of the grain from which the screening are separated shall be prefixed to "screenings oil feed."

Ground flaxseed or flaxseed meal is the product obtained by grinding flaxseed which has been screened and cleaned of weed seeds and other foreign material by the most improved commercial processes.

OAT PRODUCTS

Oat groats are the kernels of the oat berry.

Oat hulls are the outer chaffy coverings of the oat grain.

Oat middlings are the floury portions of the oat groat obtained in the milling of rolled oats.

Oat shorts are the covering of the oat grain lying immediately inside the hull, being a fuzzy material carrying with it considerable portions of the fine floury part of the groat obtained in the milling of rolled oats.

Clipped oat by-product is the resultant by-product obtained in the manufacture of clipped oats. It may contain light chaffy material broken from the ends of the hulls, empty hulls, light, immature oats and dust. It must not contain an excessive amount of oat hulls.

RICE PRODUCTS

Rice bran is the cuticle beneath the hull.

Rice hulls are the outer chaffy coverings of the rice grain.

Rice polish is the finely powdered material obtained in polishing the kernel.

WHEAT PRODUCTS

Wheat bran is the coarse outer coatings of the wheat berry obtained in the usual commercial milling process from wheat that has been cleaned and scoured.

Shorts or standard middlings are the fine particles of the outer and inner bran separated from bran and white middlings.

Wheat white middlings or white middlings are that part of the offal of wheat intermediate between shorts or standard middlings and red dog.

Shipstuff or wheat mixed feed is a mixture of the products other than the flour obtained from the milling of the wheat berry.

Red dog is a low grade wheat flour containing the finer particles of bran.

Wheat bran with mill run screenings is pure wheat bran plus the screenings which were separated from the wheat used in preparing said bran.

Wheat bran with screenings not exceeding mill run is either wheat bran with the whole mill run of screenings or wheat bran with a portion of the mill run of screenings, provided that such portion is not an inferior portion thereof.

MISCELLANEOUS PRODUCTS

Yeast or vinegar dried grains are the properly dried residue from the mixture of cereals, malt and malt sprouts (sometimes cottonseed meal) obtained in the manufacture of yeast or vinegar, and consist of corn or corn and rye from which most of the starch has been extracted, together with malt added during the manufacturing process to change the starch to sugars, and malt sprouts (sometimes cottonseed meal) added during the manufacturing process to aid in filtering the residue from the wort and serve as a source of food supply for the yeast.

Palm kernel oil meal is the ground residue from the extraction of part of the oil by pressure or solvents from the kernel of the fruit of Elaeis guineensis or Elaeis malanococca.

Ivory nut meal is ground ivory nuts.

TENTATIVE DEFINITIONS

Corn feed meal is the by-product in the manufacture of cracked corn, with or without aspiration products added to the siftings, and is the by-product obtained in the manufacture of table meal from the whole grain by the non-degerminating process.

Meat scrap and meat meal are the ground residues from animal tissues exclusive of hoof and horn. If they contain more than 10 percent of phosphoric acid (P_2O_5) they must be designated meat and bone scrap and meat and bone meal. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Digester tankage is the residue from animal tissue, exclusive of hoof and horn, specially prepared for feeding purposes by tanking under live steam, drying under high heat, and suitable grinding. If it contains more than 10 percent of phosphoric acid (P_2O_5) it must be designated digester meat and bone tankage.

Peanut oil cake is the residue after the extraction of part of the oil by pressure or solvents from peanut kernels.

Peanut oil meal is the ground residue after the extraction of part of the oil from peanut kernels.

Unhulled peanut oil feed is the ground residue obtained after extraction of part of the oil from whole peanuts, and the ingredients shall be designated as peanut meal and hulls.

III. RESULTS OF INSPECTION

The following statements touching the results of the inspection cover the entire lot of samples drawn at the holiday season. They do not include the multitudinous samples sent in by local dealers. The results are listed in the order as shown in the table of contents, page 3, and occur on pages 14 to 34.

COTTONSEED MEALS AND FEEDS

F. W. BRODÉ & Co., Memphis, Tenn. F. M. Sherman & Son, Newport; Lapelle Poultry Food Co., Swanton. *Dove.* Guaranteed to contain *38.63* percent crude protein, but failed by nearly four percent to fulfill guaranty.

(*These goods are not cottonseed meal as defined by the Association of Official Feed Analysts (page 11). They are cottonseed feed.*

BUCKEYE COTTON OIL Co., Cincinnati, O. Valley Grain Co., Brattleboro. *Buckeye Prime.* Guaranteed to contain *38.62* crude protein, but failed by three percent to fulfill guaranty.

C. L. CAMPBELL & Co., Little Rock, Ark. Adams & Davis Co., Chester. *Camel.* Guaranteed to contain *38.5* percent crude protein, but failed by more than two percent to fulfill guaranty.

S. P. DAVIS, Little Rock, Ark. Davis Feed Co., Rutland. *Veribest.* Guaranteed to contain *38.5* percent crude protein; guaranty fulfilled.

HUMPHREYS, GODWIN Co., Memphis, Tenn. Fair Haven Grist Mill, Fair Haven; E. H. Mason, Randolph; J. H. Hewitt, South Royalton; Kempton Mills, Barre; R. L. Clark, Barre; E. W. Bailey & Co., Montpelier; W. B. Johnson & Son, Essex Junction; Cunningham & Doubleday, St. Albans; City Feed Co., St. Albans; R. P. Webster, Barton; F. H. Robinson, Chester Depot; H. L. Baker, Springfield; H. P. Munson Estate, Morrisville; H. N. Gray, Cambridge; Strong & Goddard, Hyde Park. *Danish.* Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

HUMPHREYS, GODWIN Co., Memphis, Tenn. F. M. Sherman & Co., Newport. *Dixie.* Guaranteed to contain *38.62* crude protein; guaranty fulfilled.

HUMPHREYS, GODWIN Co., Memphis, Tenn. Burditt Bros., Rutland; H. K. Foster, South Royalton; J. M. Burdick, Wallingford; Kempton Mills, Barre; Berry & Jones, Montpelier; W. B. Johnson & Son, Essex Junction; A. H. McLeod Milling Co., St. Johnsbury; F. H. Robinson, Chester Depot; Corner Store, Hyde Park. *Forfat.* Guaranteed to contain *38.55* percent crude protein, but failed by one and a quarter percent to fulfill guaranty.

C. L. MONTGOMERY & Co., Memphis, Tenn. H. A. Slayton & Co., Morrisville. *Canary.* Guaranteed to contain *38.63* percent crude protein, but failed by more than two percent to fulfill guaranty.

C. L. MONTGOMERY & Co., Memphis, Tenn. W. L. Ware & Co., Chester. *Canary Extra.* Guaranteed to contain *41* percent crude protein, but failed by more than two and one-half percent to fulfill guaranty.

W. NEWTON SMITH, Baltimore, Md. E. T. & H. K. Ide, St. Johnsbury. *Dirigo.* Guaranteed to contain *38.5* percent crude protein; guaranty fulfilled.

J. E. SOPER Co., Boston, Mass. S. P. Curtis & Son, Rutland. *Pilgrim.* Guaranteed to contain *38.5* percent crude protein, but failed by two percent to fulfill guaranty.

J. E. SOPER Co., Boston, Mass. A. D. Pease, Burlington. *Pioneer.* Guaranteed to contain *41* percent crude protein, but failed by almost four and one-quarter percent to fulfill guaranty.

UNION SEED & FERTILIZER Co., Huntsville, Ala., Argenta, Ark., Clarksdale, Miss., Memphis, Tenn., Jackson, Tenn. E. M. Bixby & Son, Poultney; F. A. Sheldon, Rupert; E. H. Mason, Randolph; E. C. Crosby, Danby; J. W. Jones Co., Burlington; R. P. Webster, Barton; J. G. Turnbull Co., Orleans; St. Johnsbury Grain Co., St. Johnsbury; F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro; H. A. Slayton & Co., Morrisville. *American Red Tag.* Guaranteed to contain *38.55* percent crude protein; guaranty fulfilled.

UNION SEED & FERTILIZER Co., New York, N. Y. H. C. Skeels & Co., Swanton. *Columbia Cottonseed Feed.* Ingredients as stated by manufacturer, "Cottonseed meal and cottonseed hulls." Guaranteed to contain *20.6* percent crude protein; guaranty fulfilled.

LINSEED MEALS

AMERICAN LINSEED Co., New York, N. Y. E. T. & H. K. Ide, St. Johnsbury; St. Johnsbury Grain Co., St. Johnsbury; W. L. Ware & Co., Chester; E. Crosby & Co., Brattleboro; Valley Grain Co., Brattleboro; H. N. Gray, Cambridge; F. H. Robinson, Chester Depot. *Old Process.* Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

ARCHER-DANIELS LINSEED Co., Buffalo, N. Y. Burditt Bros., Rutland; H. K. Foster, South Royalton; H. W. Myers & Co., Bennington; Brewster River Milling Co., Jeffersonville; Frank Adams & Co., Bellows Falls; W. B. Johnson & Son, Essex Junction. *Old Process.* Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. S. P. Davis & Co., Rutland; N. N. Morse & Sons, Randolph; Kempton Mills, Barre; Berry & Jones, Montpelier; J. W. Jones Co., Burlington; City Feed Co., St. Albans; Cunningham & Doubleday, St. Albans; F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro; E. E. Harris & Co., Morrisville; George Shorey & Son, Lyndonville. *Old Process.* Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. Burlington Flouring Co., Burlington. *Old Process.* Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

TOLEDO SEED & OIL Co., Toledo, O. E. Crosby & Co., Brattleboro; H. L. Baker, Springfield. *Old Process.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

TRADERS AND PRODUCERS SUPPLY Co., Buffalo, N. Y. R. P. Webster, Barton; H. N. Brown & Co., Castleton. *Old Process.* Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

WAVER, RYAN & Co.; Buffalo, N. Y. R. L. Clark, Barre; E. W. Bailey & Co., Montpelier. ————. Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

GLUTEN FEEDS, ETC.

AMERICAN HOMINY Co., Indianapolis, Ind. Burlington Flouring Co., Burlington. *Homcoline Feed* (Corn germ meal). Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. J. W. Jones Co., Burlington; Cunningham & Doubleday, St. Albans; E. Crosby & Co., Brattleboro. *Cream of Corn.* Guaranteed to contain *24* percent crude protein, but failed by nearly two percent to fulfill guaranty.

CLINTON SUGAR REFINING Co., Clinton, Iowa. A. W. Washburn, Bethel; R. L. Clark, Barre; E. W. Bailey & Co., Montpelier; F. M. Sherman & Son, Newport; H. L. Baker, Springfield; E. E. Harris & Co., Morrisville; A. D. Pease, Burlington. *Clinton.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. J. M. Burdick, Wallingford; H. K. Foster, South Royalton; Berry & Jones, Montpelier; City Feed Co., St. Albans; W. B. Johnson & Son, Essex Junction; A. H. McLeod Milling Co., St. Johnsbury; J. G. Turnbull Co., Orleans; Adams & Davis Co., Chester; E. Crosby & Co., Brattleboro; Valley Grain Co., Brattleboro; E. E. Harris & Co., Morrisville; Brewster River Milling Co., Jeffersonville. *Buffalo.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. E. M. Bixby & Son., Poultney. *Buffalo.* Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. Fair Haven Grist Mill, Fair Haven; Burditt Bros., Rutland. *Globe.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DOUGLAS Co., Cedar Rapids, Iowa. E. H. Mason, Randolph. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

A. E. STALEY MANUFACTURING Co., Decatur, Ill. E. T. & H. K. Ide, St. Johnsbury. *Staley's.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

R. P. WEBSTER, Barton, Vt. R. P. Webster, Barton. *Bulk.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DISTILLERS' DRIED GRAINS

AJAX MILLING AND FEED Co., New York, N. Y. E. M. Bixby & Son, Poultney; Berry & Jones, Montpelier; W. B. Johnson & Son, Essex Junction; F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

AMERICAN MILLING Co., Peoria, Ill. Kempton Mills, Barre; E. W. Bailey & Co., Montpelier. *Empire State Dairy Feed.* Guaranteed to contain *30* percent crude protein, but failed by three percent to fulfill guaranty.

CLARKE BROS. & Co., Peoria, Ill. Strong & Goddard, Hyde Park; City Feed Co., St. Albans; J. G. Turnbull Co., Orleans. *Empire State Dairy Feed.* Ingredients not stated by manufacturer (illegal). Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

CLARKE BROS. & Co., Peoria, Ill. E. E. Harris & Co., Morrisville. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein; guaranty fulfilled.

DEWEY BROS Co., Blanchester, O. C. F. Wright, Bellows Falls. *Bourbon 3D Dewey.* Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. Cunningham & Doubleday, St. Albans; H. M. Brown & Co., Castleton; C. F. Wright, Bellows Falls. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein, but failed by three-fourths percent to fulfill guaranty.

HOTTELET Co., Milwaukee, Wis. E. H. Mason, Randolph; Half Century Store, Randolph; E. C. Crosby, Danby; R. L. Clark, Barre; R. P. Webster, Barton; A. H. McLeod Milling Co., St. Johnsbury; W. L. Ware & Co., Chester; E. Crosby & Co., Brattleboro; E. E. Harris & Co., Morrisville; H. N. Gray, Cambridge; J. M. Burdick, Wallingford. *Hector.* Guaranteed to contain *30* percent crude protein: guaranty fulfilled.

UBIKO MILLING Co., Cincinnati, O. S. P. Curtis & Son, Rutland; Kempton Mills, Barre; Cunningham & Doubleday, St. Albans; E. T. & H. K. Ide, St. Johnsbury; J. G. Turnbull Co., Orleans; H. K. Foster, South Royalton. *Fourex.* Guaranteed to contain *31* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

BREWERS' DRIED GRAINS

ANHEUSER-BUSCH BREWING ASSOCIATION, St. Louis, Mo. City Feed Co., St. Albans; J. G. Turnbull Co., Orleans; H. N. Gray, Cambridge. *Steam Dried.* Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

BURKHARDT BREWING Co., Roxbury Station, Mass. E. Crosby & Co., Brattleboro. *Burkhardt's.* Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

FARMERS' FEED Co., New York, N. Y. S. P. Curtis & Son, Rutland; E. H. Mason, Randolph; W. B. Johnson & Son, Essex Junction; Cunningham & Doubleday, St. Albans. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FARMERS' FEED Co., Buffalo, N. Y. A. D. Pease, Burlington. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FLEISCHMANN Co., Chicago, Ill. E. H. Mason, Randolph; J. W. Jones Co., Burlington; R. P. Webster, Barton; E. E. Harris & Co., Morrisville; W. B. Johnson & Son, Essex Junction. *Fleischmann's.* Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

K. & E. NEUMOND, St. Louis, Mo. H. A. Slayton & Co., Morrisville. *Golden Kalb.* Guaranteed to contain *2¼* percent crude protein; guaranty fulfilled.

WHEAT OFFALS

WHEAT BRANS

ANSTED & BURK Co., Springfield, O. H. N. Gray, Cambridge. *Bran* with screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

E. W. BAILEY & Co., Montpelier, Vt. R. P. Webster, Barton; J. G. Turnbull Co., Orleans. *Pennant Pure.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

BARBER MILLING Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro; J. H. Hewitt, South Royalton. *Pure Bran Flakes.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BILL, BELL & Co., Ogdensburg, N. Y. W. L. Ware & Co., Chester. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14.25* percent crude protein; guaranty fulfilled.

BLAISDELL MILLING Co., Detroit, Mich. E. E. Harris & Co., Morrisville; J. H. Hewitt, South Royalton. *Detroit Coarse Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Cereal Bran.* Not guaranteed; contained *12.4* percent crude protein.

CANNON VALLEY MILLING Co., Minneapolis, Minn. Valley Grain Co., Brattleboro; H. N. Gray, Cambridge. *Cannon Valley Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WM. A. COOMBES MILLING Co., Coldwater, Mich. J. H. Hewitt, South Royalton. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. J. H. Hewitt, South Royalton. *Monogram Fancy Pure Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

B. A. ECKHARDT MILLING Co., Chicago, Ill. H. M. Brown & Co., Castleton. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. A. N. Washburn, Bethel. *Dairy Maid Winter Wheat Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. R. L. Clark, Barre; George Shorey & Son, Lyndonville. *Lucky Spring Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

GWINN MILLING Co., Columbus, O. R. P. Webster, Barton; H. A. Slayton & Co., Morrisville. *Gwinn's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEHLOR FLOUR MILLS CO., St. Louis, Mo. Frank Adams & Co., Bellows Falls. *Palace Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR CO., Kansas City, Mo. J. W. Jones Co., Burlington; E. T. & H. K. Ide, St. Johnsbury; F. H. Robinson, Chester Depot. *Anchor Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR CO., Kansas City, Mo. E. W. Bailey & Co., Montpelier. *Anchor Bran* with ground wheat screenings not exceeding mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING CO., La Crosse, Wis. H. L. Baker, Springfield. *Elmco Fancy Bran.* Guaranteed to contain *15.51* percent crude protein, but failed by three-fourths percent to fulfill guaranty.

MAPLE LEAF MILLING CO., LTD., Toronto, Can. Strong & Goddard, Hyde Park. *Bran.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NATIONAL FEED CO., St. Louis, Mo. E. T. Seabury Estate, Waterbury. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NATIONAL FEED CO., St. Louis, Mo. Burlington Flouring Co., Burlington. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING CO., Niagara Falls, N. Y. C. F. Wright, Bellows Falls. *Choice Bran.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS CO., Montreal, Que. R. P. Webster, Barton; A. D. Pease, Burlington. *Nunograin Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS CO., Montreal, Que. Burlington Flouring Co., Burlington. *Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS CO., Minneapolis, Minn. F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro; Brewster River Milling Co., Jeffersonville; Burditt Bros., Rutland; F. A. Sheldon, Rupert. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS CO., Minneapolis, Minn. R. P. Webster, Barton. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS CO., Minneapolis, Minn. H. A. Slayton & Co., Morrisville. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

QUAKER CITY FLOUR MILLS CO., Philadelphia, Pa. E. Crosby & Co., Brattleboro. *Quaker City Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

ROYAL MILLING CO., Great Falls, Mont. R. P. Webster, Barton. *Royal Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING CO., Minneapolis, Minn. Kempton Mills, Barre; H. L. Baker, Springfield; E. E. Harris & Co., Morrisville. *Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

SOUTHWESTERN MILLING CO., Kansas City, Mo. J. W. Jones Co., Burlington. *Pure Bran.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. E. Crosby & Co., Brattleboro; A. D. Pease, Burlington. *Winter Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. *Spring Bran* with ground clear wheat screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

STRATTON & CO., Concord, N. H. H. L. Baker, Springfield. *Fancy Bran,* mill-run screenings ground in. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. F. M. Sherman & Son, Newport. *Winter Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. F. M. Sherman & Son, Newport. *Angelus Winter Wheat Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. Brewster River Milling Co., Jeffersonville. *Waumbeck Silver Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. F. H. Robinson, Chester Depot. *Crescent Bran* containing mill-run screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. Half Century Store, Randolph; J. M. Burdick, Wallingford; E. W. Bailey & Co., Montpelier; City Feed Co., St. Albans; Cunningham & Doubleday, St. Albans; E. Crosby & Co., Brattleboro; E. E. Harris & Co., Morrisville; Corner Store, Hyde Park; Fair Haven Grist Mill, Fair Haven; E. H. Mason, Randolph. *Washburn-Crosby's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. Burlington Flouring Co., Burlington. *Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WESTERN FLOUR MILL Co., Davenport, Ia. H. C. Skeels & Co., Swanton. *Blackhawk Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13.1* percent crude protein; guaranty fulfilled.

WHEAT MIDDLINGS

ANSTED & BURK Co., Springfield, O. J. G. Turnbull Co., Orleans. *William Tell Middlings.* Guaranteed to contain *15* per cent crude protein; guaranty contain *15* percent crude protein; guaranty fulfilled.

BAY STATE MILLING Co., Winona, Minn. E. M. Bixby & Son, Poultney. *Winona Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

BELL, BELL & Co., Ogdensburg, N. Y. A. N. Washburn, Bethel; H. L. Baker, Springfield. *Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *16.5* percent crude protein, but failed by almost three-fourths percent to fulfill guaranty.

BELL, BELL & Co., Ogdensburg, N. Y. H. L. Baker, Springfield. *Wise King Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CANNON VALLEY MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Cannon Valley Middlings.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

CLARO MILLING Co., Lakeville, Minn. H. C. Skeels & Co., Swanton. *Claro Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WM. A. COOMBES Co., Coldwater, Mich. J. H. Hewitt, South Royalton; City Feed Co., St. Albans. *Rob Roy Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. R. L. Clark, Barre. *Wirthmore Middlings* (wheat middlings and red dog flour). Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

DETROIT MILLING Co., Detroit, Mich. E. Crosby & Co., Brattleboro. *Aper Middlings.* Guaranteed to contain *16* percent crude protein, but failed by almost two-thirds percent to fulfill guaranty.

DETROIT MILLING Co., Detroit, Mich. H. L. Baker, Springfield. *Apex Middlings.* Guaranteed to contain *17* percent crude protein, but failed by almost one and one-half percent to fulfill guaranty.

FEDERAL MILLING Co., Lockport, N. Y. E. T. & H. K. Ide, St. Johnsbury. *Dairy Maid Winter Wheat Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15.5* percent protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. A. D. Pease, Burlington. *Dairy Maid Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. City Feed Co., St. Albans. *Lucky Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. S. P. Curtis & Son. Rutland. *Standard Middlings*, with mill-run screenings. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

HUBBARD MILLING Co., Mankato, Minn. R. L. Clarke, Barre. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

HUBBARD MILLING Co., Mankato, Minn. Burlington Flouring Co., Burlington. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-half percent to fulfill guaranty.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. E. Crosby & Co., Brattleboro. *Carnation Gray Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., La Crosse, Wis. George Shorey & Son, Lyndonville. *Elmco Fancy White Middlings* with screenings. Guaranteed to contain *15.96* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. W. B. Johnson & Son, Essex Junction; Cunningham & Doubleday, St. Albans. *Choice Middlings*. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. W. B. Johnson & Son, Essex Junction. *XXX Comet Middlings*. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. R. L. Clark, Barre; E. W. Bailey & Co., Montpelier; H. C. Skeels & Co., Swanton. *Pillsbury's Standard Brown Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. Valley Grain Co., Brattleboro. *Duram Wheat Standard Middlings*. Guaranteed to contain *12.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro. *Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. H. K. Foster, South Royalton. *Daisy Middlings*. Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. H. P. Munson Estate, Morrisville. *Daisy Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

STANDARD MILLING Co. Mankato, Minn. W. L. Ware & Co., Chester. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. H. C. Skeels & Co., Swanton; E. Crosby & Co., Brattleboro. *Stott's Fine White Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. A. D. Pease, Burlington. *Stott's Pennant Middlings*. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Adams & Davis Co., Chester. *Farmers' Favorite Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. A. D. Pease, Burlington. *Waumbeck Dairy Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. H. A. Slayton & Co., Morrisville. *Waumbeck Pearl Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING CO., Grand Rapids, Mich. E. E. Harris & Co., Morrisville. *Crescent Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY CO., Minneapolis, Minn. Fair Haven Grist Mill, Fair Haven; E. H. Mason, Randolph; J. M. Burdick, Wallingford; Half Century Store, Randolph; H. K. Foster, South Royalton; F. H. Robinson, Chester Depot. *Washburn-Crosby's Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WHEAT MIXED FEEDS

E. W. BAILEY & CO., Montpelier, Vt. E. W. Bailey & Co., Montpelier; W. L. Ware & Co., Chester; Strong & Goddard, Hyde Park. *Bailey's Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

E. W. BAILEY & CO., Montpelier, Vt. E. W. Bailey & Co., Montpelier. *Bailey's Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BILL BELL & CO., Ogdensburg, N. Y. W. L. Ware & Co., Chester. *Wise King Middlings Feed* with ground screenings. Guaranteed to contain *16* percent crude protein, but failed by almost two-thirds percent to fulfill guaranty.

CHAS. M. COX CO., Boston, Mass. George Shorey & Son, Lyndonville. *Wirthmore Wheat Feed* (wheat bran and red dog with less than mill-run of screenings). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. Cunningham & Doubleday, St. Albans; H. N. Gray, Cambridge. *Wirthmore Wheat Feed* (wheat bran and red dog flour with less than mill-run of screenings). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WILLIAM CROCKER, Buffalo, N. Y. F. A. Sheldon, Rupert. *Wm. Crocker's Wheat Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

E. CROSBY & CO., Brattleboro, Vt. St. Johnsbury Grain Co., St. Johnsbury; Frank Adams & Co., Bellows Falls. *Crosby's Fancy Middlings and Feed.* Guaranteed to contain *17.53* percent crude protein, but failed by more than two percent to fulfill guaranty.

E. CROSBY & CO., Brattleboro, Vt. E. Crosby & Co. *Crosby's Pure Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DULUTH SUPERIOR MILLING CO., Duluth, Minn. E. E. Harris & Co., Morrisville. *Boston Mixed Feed* (bran, middlings), low grade of flour with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. N. Washburn, Bethel. *Lucky Spring Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

GARLAND MILLING CO., Greensburg, Ind. E. T. & H. K. Ide, St. Johnsbury. *Garland Mixed Feed;* winter wheat product, bran, middlings, screenings not exceeding mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

E. E. HARRIS & CO., Morrisville, Vt. E. E. Harris & Co., Morrisville. *Regular Wheat Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

HARTER MILLING CO., Toledo, O. C. F. Wright, Bellows Falls. *Harter's Mainspring Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING CO., Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Hecker's Mixed Feed* with mill-run screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. E. T. & H. K. Ide, St. Johnsbury. *Ideal Fancy Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

F. W. KELLEY Co., St. Johnsbury, Vt. F. M. Sherman, Newport. *Blue Tag Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. KELLEY Co., St. Johnsbury, Vt. A. H. McLeod Milling Co., St. Johnsbury. *Blue Tag Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

A. H. MCLEOD Co., St. Johnsbury, Vt. A. H. McLeod Milling Co., St. Johnsbury. *Brooks' Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NATIONAL MILLING Co., Toledo, O. N. N. Morse & Sons, Randolph. *Osota Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. E. T. Seabury Estate, Waterbury; R. P. Webster, Barton; F. H. Robinson, Chester Depot; J. W. Jones Co., Burlington. *Planet Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Davis Feed Co., Rutland. *Comet Mixed Feed* and ground screenings not exceeding mill-run. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. W. Bailey & Co., Montpelier; E. H. Mason, Randolph; E. Crosby & Co., Brattleboro; H. A. Slayton & Co., Morrisville. *Fancy Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. Half Century Store, Randolph; Brewster River Milling Co., Jeffersonville; E. T. & H. K. Ide, St. Johnsbury. *Champion Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.56* percent crude protein; guaranty fulfilled.

RICHARDTON ROLLER MILLS, Richardton, N. Dak. E. T. & H. K. Ide, St. Johnsbury. *Richardton Mixed Feed* (bran, middlings, shorts and wheat screenings not exceeding mill-run). Guaranteed to contain *16.7* percent crude protein, but failed by almost one and one-half percent to fulfill guaranty.

ROYAL MILLING Co., Great Falls, Mont. C. F. Wright, Bellows Falls. *Royal Mixed Feed* (wheat bran, flour and ground screenings not exceeding mill-run). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. Valley Grain Co., Brattleboro. *Occident Wheat Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. H. P. Munson Estate, Morrisville; R. P. Webster, Barton; E. W. Bailey & Co., Montpelier. *Occident Wheat Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

ST. ALBANS GRAIN Co., St. Albans, Vt. W. B. Johnson & Son, Essex Junction. *Hygrade Mixed Feed* (bran and red dog with less than mill-run of screenings). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

SHEFFIELD-KING MILLING Co., Minneapolis, Minn. J. G. Turnbull Co., Orleans. *Gold Mine* (bran, shorts, flour, wheat products and pulverized screenings). Guaranteed to contain *15.9* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. E. Crosby & Co., Brattleboro. *Try Me Winter Mixed Feed* (bran, middlings and ground screenings not exceeding mill-run). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. W. B. Johnson & Son, Essex Junction. *Monarch Fancy Wheat Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. E. H. Mason, Randolph. *Stott's Honest Mixed Feed.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. City Feed Co., St. Albans. *Stott's Heavy Pure Mixed Wheat Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. A. D. Pease, Burlington. *Stott's Pure Wheat Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

STRATTON & Co., Concord, N. H. H. L. Baker, Springfield. *Stratton's Mixed Feed.* Guaranteed to contain *15.87* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. S. Sherman & Son, Inc., Poultney. *Angelus Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. E. E. Harris & Co., Morrisville. *Farmers' Favorite Wheat Cow Feed.* Guaranteed to contain *12.71* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Frank Adams & Co., Bellows Falls. *Farmers' Favorite Cow Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *15.68* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. W. L. Ware & Co., Chester. *Mill-run Bran Mixed Feed.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. Burditt Bros., Rutland. *Waggoner-Gates Mixed Feed* (mill-run bran, middlings and ship stuff). Guaranteed to contain *15.1* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. J. M. Burdick, Wallingford; Davis Feed Co., Rutland; F. A. Sheldon, Rupert. *Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. F. A. Sheldon, Rupert. *Wheat Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15.1* percent crude protein; guaranty fulfilled.

WILLIAMS BROS., Kent, O. Burditt Bros., Rutland. *Kent Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

RED DOG FLOUR

BAY STATE MILLING Co., Winona, Minn. E. M. Bixby & Son, Poultney. ———. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL Co., Buffalo, N. Y. S. P. Curtis & Son, Rutland. ———. Guaranteed to contain *16.75* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., La Crosse, Wis. N. N. Morse & Sons, Randolph. *Elmco.* Guaranteed to contain *15.91* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. Cunningham & Doubleday, St. Albans. *Choice.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. R. P. Webster, Barton. *XXX Comet.* Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. J. M. Burdick, Wallingford. *Daisy.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. W. Bailey & Co., Montpelier. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. A. D. Pease, Burlington. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. Lapelle Poultry Food Co., Swanton. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro. *Daisy.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. W. L. Ware & Co., Chester. *Pure Hard Wheat Adrain.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. J. M. Burdick, Wallingford; H. K. Foster, South Royalton; Berry & Jones, Montpelier; City Feed Co., St. Albans; W. B. Johnson & Son, Essex Junction; A. H. McLeod Milling Co., St. Johnsbury; J. G. Turnbull Co., Orleans; Adams & Davis Co., Chester; E. Crosby & Co., Brattleboro; Valley Grain Co., Brattleboro; E. E. Harris & Co., Morrisville; Brewster River Milling Co., Jeffersonville. *Buffalo.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. E. M. Bixby & Son., Poultney. *Buffalo.* Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING Co., New York, N. Y. Fair Haven Grist Mill, Fair Haven; Burditt Bros., Rutland. *Globe.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DOUGLAS Co., Cedar Rapids, Iowa. E. H. Mason, Randolph. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

A. E. STALEY MANUFACTURING Co., Decatur, Ill. E. T. & H. K. Ide, St. Johnsbury. *Staley's.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

R. P. WEBSTER, Barton, Vt. R. P. Webster, Barton. *Bulk.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

DISTILLERS' DRIED GRAINS

AJAX MILLING AND FEED Co., New York, N. Y. E. M. Bixby & Son, Poultney; Berry & Jones, Montpelier; W. B. Johnson & Son, Essex Junction; F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

AMERICAN MILLING Co., Peoria, Ill. Kempton Mills, Barre; E. W. Bailey & Co., Montpelier. *Empire State Dairy Feed.* Guaranteed to contain *30* percent crude protein, but failed by three percent to fulfill guaranty.

CLARKE BROS. & Co., Peoria, Ill. Strong & Goddard, Hyde Park; City Feed Co., St. Albans; J. G. Turnbull Co., Orleans. *Empire State Dairy Feed.* Ingredients not stated by manufacturer (illegal). Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

CLARKE BROS. & Co., Peoria, Ill. E. E. Harris & Co., Morrisville. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein; guaranty fulfilled.

DEWEY BROS Co., Blanchester, O. C. F. Wright, Bellows Falls. *Bourbon 3D Dewey.* Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. Cunningham & Doubleday, St. Albans; H. M. Brown & Co., Castleton; C. F. Wright, Bellows Falls. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein, but failed by three-fourths percent to fulfill guaranty.

HOTTELET Co., Milwaukee, Wis. E. H. Mason, Randolph; Half Century Store, Randolph; E. C. Crosby, Danby; R. L. Clark, Barre; R. P. Webster, Barton; A. H. McLeod Milling Co., St. Johnsbury; W. L. Ware & Co., Chester; E. Crosby & Co., Brattleboro; E. E. Harris & Co., Morrisville; H. N. Gray, Cambridge; J. M. Burdick, Wallingford. *Hector.* Guaranteed to contain *30* percent crude protein: guaranty fulfilled.

UBIKO MILLING Co., Cincinnati, O. S. P. Curtis & Son, Rutland; Kempton Mills, Barre; Cunningham & Doubleday, St. Albans; E. T. & H. K. Ide, St. Johnsbury; J. G. Turnbull Co., Orleans; H. K. Foster, South Royalton. *Fourex.* Guaranteed to contain *31* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

BREWERS' DRIED GRAINS

ANHEUSER-BUSCH BREWING ASSOCIATION, St. Louis, Mo. City Feed Co., St. Albans; J. G. Turnbull Co., Orleans; H. N. Gray, Cambridge. *Steam Dried.* Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

BURKHARDT BREWING Co., Roxbury Station, Mass. E. Crosby & Co., Brattleboro. *Burkhardt's.* Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

FARMERS' FEED Co., New York, N. Y. S. P. Curtis & Son, Rutland; E. H. Mason, Randolph; W. B. Johnson & Son, Essex Junction; Cunningham & Doubleday, St. Albans. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FARMERS' FEED Co., Buffalo, N. Y. A. D. Pease, Burlington. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

FLEISCHMANN Co., Chicago, Ill. E. H. Mason, Randolph; J. W. Jones Co., Burlington; R. P. Webster, Barton; E. E. Harris & Co., Morrisville; W. B. Johnson & Son, Essex Junction. *Fleischmann's.* Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

K. & E. NEUMOND, St. Louis, Mo. H. A. Slayton & Co., Morrisville. *Golden Kalb.* Guaranteed to contain *2¼* percent crude protein; guaranty fulfilled.

WHEAT OFFALS

WHEAT BRANS

ANSTED & BURK Co., Springfield, O. H. N. Gray, Cambridge. *Bran* with screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

E. W. BAILEY & Co., Montpelier, Vt. R. P. Webster, Barton; J. G. Turnbull Co., Orleans. *Pennant Pure.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

BARBER MILLING Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro; J. H. Hewitt, South Royalton. *Pure Bran Flakes.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BILL, BELL & Co., Ogdensburg, N. Y. W. L. Ware & Co., Chester. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14.25* percent crude protein; guaranty fulfilled.

BLAISDELL MILLING Co., Detroit, Mich. E. E. Harris & Co., Morrisville; J. H. Hewitt, South Royalton. *Detroit Coarse Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Cereal Bran.* Not guaranteed; contained *12.4* percent crude protein.

CANNON VALLEY MILLING Co., Minneapolis, Minn. Valley Grain Co., Brattleboro; H. N. Gray, Cambridge. *Cannon Valley Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WM. A. COOMBES MILLING Co., Coldwater, Mich. J. H. Hewitt, South Royalton. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. J. H. Hewitt, South Royalton. *Monogram Fancy Pure Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

B. A. ECKHARDT MILLING Co., Chicago, Ill. H. M. Brown & Co., Castleton. *Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. A. N. Washburn, Bethel. *Dairy Maid Winter Wheat Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. R. L. Clark, Barre; George Shorey & Son, Lyndonville. *Lucky Spring Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

GWINN MILLING Co., Columbus, O. R. P. Webster, Barton; H. A. Slayton & Co., Morrisville. *Gwinn's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEHLOR FLOUR MILLS Co., St. Louis, Mo. Frank Adams & Co., Bellows Falls. *Palace Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. J. W. Jones Co., Burlington; E. T. & H. K. Ide, St. Johnsbury; F. H. Robinson, Chester Depot. *Anchor Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. E. W. Bailey & Co., Montpelier. *Anchor Bran* with ground wheat screenings not exceeding mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., La Crosse, Wis. H. L. Baker, Springfield. *Elmco Fancy Bran.* Guaranteed to contain *15.51* percent crude protein, but failed by three-fourths percent to fulfill guaranty.

MAPLE LEAF MILLING Co., LTD., Toronto, Can. Strong & Goddard, Hyde Park. *Bran.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NATIONAL FEED Co., St. Louis, Mo. E. T. Seabury Estate, Waterbury. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NATIONAL FEED Co., St. Louis, Mo. Burlington Flouring Co., Burlington. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. C. F. Wright, Bellows Falls. *Choice Bran.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Montreal, Que. R. P. Webster, Barton; A. D. Pease, Burlington. *Nunograin Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Montreal, Que. Burlington Flouring Co., Burlington. *Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro; Brewster River Milling Co., Jeffersonville; Burditt Bros., Rutland; F. A. Sheldon, Rupert. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. R. P. Webster, Barton. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. H. A. Slayton & Co., Morrisville. *Pillsbury's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

QUAKER CITY FLOUR MILLS Co., Philadelphia, Pa. E. Crosby & Co., Brattleboro. *Quaker City Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

ROYAL MILLING Co., Great Falls, Mont. R. P. Webster, Barton. *Royal Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. Kempton Mills, Barre; H. L. Baker, Springfield; E. E. Harris & Co., Morrisville. *Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

SOUTHWESTERN MILLING Co., Kansas City, Mo. J. W. Jones Co., Burlington. *Pure Bran.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. E. Crosby & Co., Brattleboro; A. D. Pease, Burlington. *Winter Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. *Spring Bran* with ground clear wheat screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

STRATTON & Co., Concord, N. H. H. L. Baker, Springfield. *Fancy Bran,* mill-run screenings ground in. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. F. M. Sherman & Son, Newport. *Winter Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. F. M. Sherman & Son, Newport. *Angelus Winter Wheat Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. Brewster River Milling Co., Jeffersonville. *Waumbeck Silver Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. F. H. Robinson, Chester Depot. *Crescent Bran* containing mill-run screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. Half Century Store, Randolph; J. M. Burdick, Wallingford; E. W. Bailey & Co., Montpelier; City Feed Co., St. Albans; Cunningham & Doubleday, St. Albans; E. Crosby & Co., Brattleboro; E. E. Harris & Co., Morrisville; Corner Store, Hyde Park; Fair Haven Grist Mill, Fair Haven; E. H. Mason, Randolph. *Washburn-Crosby's Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. Burlington Flouring Co., Burlington. *Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WESTERN FLOUR MILL Co., Davenport, Ia. H. C. Skeels & Co., Swanton. *Blackhawk Bran* with ground screenings not exceeding mill-run. Guaranteed to contain *13.1* percent crude protein; guaranty fulfilled.

WHEAT MIDDLINGS

ANSTED & BURK Co., Springfield, O. J. G. Turnbull Co., Orleans. *William Tell Middlings.* Guaranteed to contain *15* per cent crude protein; guaranty contain *15* percent crude protein; guaranty fulfilled.

BAY STATE MILLING Co., Winona, Minn. E. M. Bixby & Son, Poultney. *Winona Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

BILL, BELL & Co., Ogdensburg, N. Y. A. N. Washburn, Bethel; H. L. Baker, Springfield. *Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *16.5* percent crude protein, but failed by almost three-fourths percent to fulfill guaranty.

BILL, BELL & Co., Ogdensburg, N. Y. H. L. Baker, Springfield. *Wise King Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CANNON VALLEY MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Cannon Valley Middlings.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

CLARO MILLING Co., Lakeville, Minn. H. C. Skeels & Co., Swanton. *Claro Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WM. A. COOMBES Co., Coldwater, Mich. J. H. Hewitt, South Royalton; City Feed Co., St. Albans. *Rob Roy Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. R. L. Clark, Barre. *Wirthmore Middlings* (wheat middlings and red dog flour). Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

DETROIT MILLING Co., Detroit, Mich. E. Crosby & Co., Brattleboro. *Aper Middlings.* Guaranteed to contain *16* percent crude protein, but failed by almost two-thirds percent to fulfill guaranty.

DETROIT MILLING Co., Detroit, Mich. H. L. Baker, Springfield. *Apex Middlings.* Guaranteed to contain *17* percent crude protein, but failed by almost one and one-half percent to fulfill guaranty.

FEDERAL MILLING Co., Lockport, N. Y. E. T. & H. K. Ide, St. Johnsbury. *Dairy Maid Winter Wheat Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *13.5* percent protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. D. Pease, Burlington. *Dairy Maid Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. City Feed Co., St. Albans. *Lucky Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. S. P. Curtis & Son. Rutland. *Standard Middlings*, with mill-run screenings. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

HUBBARD MILLING Co., Mankato, Minn. R. L. Clarke, Barre. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

HUBBARD MILLING Co., Mankato, Minn. Burlington Flouring Co., Burlington. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-half percent to fulfill guaranty.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. E. Crosby & Co., Brattleboro. *Carnation Gray Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., La Crosse, Wis. George Shorey & Son, Lyndonville. *Elmco Fancy White Middlings* with screenings. Guaranteed to contain *15.96* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. W. B. Johnson & Son, Essex Junction; Cunningham & Doubleday, St. Albans. *Choice Middlings*. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. W. B. Johnson & Son, Essex Junction. *XXX Comet Middlings*. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. R. L. Clark, Barre; E. W. Bailey & Co., Montpelier; H. C. Skeels & Co., Swanton. *Pillsbury's Standard Brown Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. Valley Grain Co., Brattleboro. *Duram Wheat Standard Middlings*. Guaranteed to contain *12.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro. *Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. H. K. Foster, South Royalton. *Daisy Middlings*. Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. H. P. Munson Estate, Morrisville. *Daisy Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

STANDARD MILLING Co. Mankato, Minn. W. L. Ware & Co., Chester. *Standard Fine Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *18.7* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. H. C. Skeels & Co., Swanton; E. Crosby & Co., Brattleboro. *Stott's Fine White Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. A. D. Pease, Burlington. *Stott's Pennant Middlings*. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Adams & Davis Co., Chester. *Farmers' Favorite Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. A. D. Pease, Burlington. *Waumbeck Dairy Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. H. A. Slayton & Co., Morrisville. *Waumbeck Pearl Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. E. E. Harris & Co., Morrisville. *Crescent Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. Fair Haven Grist Mill, Fair Haven; E. H. Mason, Randolph; J. M. Burdick, Wallingford; Half Century Store, Randolph; H. K. Foster, South Royalton; F. H. Robinson, Chester Depot. *Washburn-Crosby's Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WHEAT MIXED FEEDS

E. W. BAILEY & Co., Montpelier, Vt. E. W. Bailey & Co., Montpelier; W. L. Ware & Co., Chester; Strong & Goddard, Hyde Park. *Bailey's Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

E. W. BAILEY & Co., Montpelier, Vt. E. W. Bailey & Co., Montpelier. *Bailey's Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BILL BELL & Co., Ogdensburg, N. Y. W. L. Ware & Co., Chester. *Wise King Middlings Feed* with ground screenings. Guaranteed to contain *16* percent crude protein, but failed by almost two-thirds percent to fulfill guaranty.

CHAS. M. COX Co., Boston, Mass. George Shorey & Son, Lyndonville. *Wirthmore Wheat Feed* (wheat bran and red dog with less than mill-run of screenings). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. Cunningham & Doubleday, St. Albans; H. N. Gray, Cambridge. *Wirthmore Wheat Feed* (wheat bran and red dog flour with less than mill-run of screenings). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WILLIAM CROCKER, Buffalo, N. Y. F. A. Sheldon, Rupert. *Wm. Crocker's Wheat Standard Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. St. Johnsbury Grain Co., St. Johnsbury; Frank Adams & Co., Bellows Falls. *Crosby's Fancy Middlings and Feed.* Guaranteed to contain *17.53* percent crude protein, but failed by more than two percent to fulfill guaranty.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co. *Crosby's Pure Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DULUTH SUPERIOR MILLING Co., Duluth, Minn. E. E. Harris & Co., Morrisville. *Boston Mixed Feed* (bran, middlings), low grade of flour with ground screenings not exceeding mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. A. N. Washburn, Bethel. *Lucky Spring Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

GARLAND MILLING Co., Greensburg, Ind. E. T. & H. K. Ide, St. Johnsbury. *Garland Mixed Feed;* winter wheat product, bran, middlings, screenings not exceeding mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

E. E. HARRIS & Co., Morrisville, Vt. E. E. Harris & Co., Morrisville. *Regular Wheat Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

HARTER MILLING Co., Toledo, O. C. F. Wright, Bellows Falls. *Harter's Mainspring Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Hecker's Mixed Feed* with mill-run screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. E. T. & H. K. Ide, St. Johnsbury. *Ideal Fancy Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

F. W. KELLEY Co., St. Johnsbury, Vt. F. M. Sherman, Newport. *Blue Tag Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. KELLEY Co., St. Johnsbury, Vt. A. H. McLeod Milling Co., St. Johnsbury. *Blue Tag Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

A. H. MCLEOD Co., St. Johnsbury, Vt. A. H. McLeod Milling Co., St. Johnsbury. *Brooks' Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NATIONAL MILLING Co., Toledo, O. N. N. Morse & Sons, Randolph. *Osota Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. E. T. Seabury Estate, Waterbury; R. P. Webster, Barton; F. H. Robinson, Chester Depot; J. W. Jones Co., Burlington. *Planet Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Davis Feed Co., Rutland. *Comet Mixed Feed* and ground screenings not exceeding mill-run. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. W. Bailey & Co., Montpelier; E. H. Mason, Randolph; E. Crosby & Co., Brattleboro; H. A. Slayton & Co., Morrisville. *Fancy Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. Half Century Store, Randolph; Brewster River Milling Co., Jeffersonville; E. T. & H. K. Ide, St. Johnsbury. *Champion Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.56* percent crude protein; guaranty fulfilled.

RICHARDTON ROLLER MILLS, Richardton, N. Dak. E. T. & H. K. Ide, St. Johnsbury. *Richardton Mixed Feed* (bran, middlings, shorts and wheat screenings not exceeding mill-run). Guaranteed to contain *16.7* percent crude protein, but failed by almost one and one-half percent to fulfill guaranty.

ROYAL MILLING Co., Great Falls, Mont. C. F. Wright, Bellows Falls. *Royal Mixed Feed* (wheat bran, flour and ground screenings not exceeding mill-run). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. Valley Grain Co., Brattleboro. *Occident Wheat Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. H. P. Munson Estate, Morrisville; R. P. Webster, Barton; E. W. Bailey & Co., Montpelier. *Occident Wheat Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

ST. ALBANS GRAIN Co., St. Albans, Vt. W. B. Johnson & Son, Essex Junction. *Hygrade Mixed Feed* (bran and red dog with less than mill-run of screenings). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

SHEFFIELD-KING MILLING Co., Minneapolis, Minn. J. G. Turnbull Co., Orleans. *Gold Mine* (bran, shorts, flour, wheat products and pulverized screenings). Guaranteed to contain *15.9* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. E. Crosby & Co., Brattleboro. *Try Me Winter Mixed Feed* (bran, middlings and ground screenings not exceeding mill-run). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. W. B. Johnson & Son, Essex Junction. *Monarch Fancy Wheat Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. E. H. Mason, Randolph. *Stott's Honest Mixed Feed.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. City Feed Co., St. Albans. *Stott's Heavy Pure Mixed Wheat Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, INC., Detroit, Mich. A. D. Pease, Burlington. *Stott's Pure Wheat Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

STRATTON & Co., Concord, N. H. H. L. Baker, Springfield. *Stratton's Mixed Feed.* Guaranteed to contain *15.87* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. S. Sherman & Son, Inc., Poultney. *Angelus Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. E. E. Harris & Co., Morrisville. *Farmers' Favorite Wheat Cow Feed.* Guaranteed to contain *12.71* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Frank Adams & Co., Bellows Falls. *Farmers' Favorite Cow Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *15.68* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. W. L. Ware & Co., Chester. *Mill-run Bran Mixed Feed.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. Burditt Bros., Rutland. *Waggoner-Gates Mixed Feed* (mill-run bran, middlings and ship stuff). Guaranteed to contain *15.1* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. J. M. Burdick, Wallingford; Davis Feed Co., Rutland; F. A. Sheldon, Rupert. *Mixed Feed* with ground screenings not exceeding mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. F. A. Sheldon, Rupert. *Wheat Flour Middlings* with ground screenings not exceeding mill-run. Guaranteed to contain *15.1* percent crude protein; guaranty fulfilled.

WILLIAMS BROS., Kent, O. Burditt Bros., Rutland. *Kent Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

RED DOG FLOUR

BAY STATE MILLING Co., Winona, Minn. E. M. Bixby & Son, Poultney. ———. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL Co., Buffalo, N. Y. S. P. Curtis & Son, Rutland. ———. Guaranteed to contain *16.75* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., La Crosse, Wis. N. N. Morse & Sons, Randolph. *Elmco.* Guaranteed to contain *15.91* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. Cunningham & Doubleday, St. Albans. *Choice.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. R. P. Webster, Barton. *XXX Comet.* Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. J. M. Burdick, Wallingford. *Daisy.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. W. Bailey & Co., Montpelier. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. A. D. Pease, Burlington. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. Lapelle Poultry Food Co., Swanton. *XX Daisy.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

PILLSBURY FLOUR MILLS Co., Minneapolis, Minn. E. Crosby & Co., Brattleboro. *Daisy.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

WASHBURN-CROSBY Co., Minneapolis, Minn. W. L. Ware & Co., Chester. *Pure Hard Wheat Adrain.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

HOMINY FEEDS

AMERICAN HOMINY CO., Indianapolis, Ind. E. W. Bailey & Co., Montpelier; Frank Adams & Co., Bellows Falls. *Homco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BALTIMORE PEARL HOMINY CO., Baltimore, Md. Corner Store, Hyde Park. *Spring Garden.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BUFFALO CEREAL CO., Buffalo, N. Y. A. D. Pease, Burlington. *Bufceco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CEREAL MILLS, Wausau, Wis. Davis Feed Co., Rutland; F. H. Robinson, Chester Depot. ————. Guaranteed to contain *11.25* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. City Feed Store, St. Albans. *Paragon.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

DEUTSCH & SICKERT CO., Milwaukee, Wis. E. H. Mason, Randolph. *Success.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

MYSTIC MILLING CO., Sioux City, Iowa. George Shorey & Son, Lyndonville; A. H. McLeod Milling Co., St. Johnsbury. ————. Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. Adams & Davis Co., Chester. *Yellow.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

STANDARD CEREAL CO., Chillicothe, O. Frank Adams & Co., Bellows Falls. *Logan.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

SUFFERN-HUNT MILLS, Decatur, Ill. Davis Feed Co., Rutland. *Acme.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

DRIED BEET PULPS

LARROWE MILLING CO., Detroit, Mich. E. T. & H. K. Ide, St. Johnsbury. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

LARROWE MILLING CO., Detroit, Mich. Burlington Flouring Co., Burlington. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

CHARLES POPE, Chicago, Ill. H. A. Slayton & Co., Morrisville. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

ALFALFA MEALS

DENVER ALFALFA MILLING & PRODUCTS CO., Hartman, Colo. R. L. Clark, Barre. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

DENVER ALFALFA MILLING & PRODUCTS CO., Hartman, Colo. Burlington Flouring Co., Burlington. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON CO., Chicago, Ill. W. L. Ware & Co., Chester. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON CO., Chicago, Ill. E. Crosby & Co., Brattleboro. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

EMPIRE STATE ALFALFA MILLS, INC., Morrisville, N. Y. Adams & Davis Co., Chester. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

KORNFALFA FEED & MILLING CO., Kansas City, Mo. J. W. Jones Co., Burlington. *Pioneer.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

PARK & POLLARD CO., Boston, Mass. H. W. Myers & Co., Bennington. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

M. C. PETERS MILLING CO., Omaha, Neb. E. Crosby & Co., Brattleboro. *Lucerne Pure.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

RALSTON-PURINA CO., St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

SOMERS & CO., San Francisco, Cal. J. W. Jones Co., Burlington. *Red Star.* Guaranteed to contain *16.6* percent crude protein, but failed by one and three-fourths percent to fulfill guaranty.

OTTO WEISS MILLING Co., Wichita, Kan. Adams & Davis Co., Chester. ———. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

OTTO WEISS MILLING Co., Wichita, Kan. Burditt Bros., Rutland. ———. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

———. E. W. Bailey & Co., Montpelier. ———. (Unguaranteed); contained *14.5* percent crude protein.

———. St. Albans Grain Co., St. Albans. ———. (Unguaranteed); contained *16.3* percent crude protein.

PROPRIETARY FEEDS

DAIRY, STOCK, HORSE

ARCADY FARMS MILLING Co., Chicago, Ill. E. Crosby & Co., Brattleboro. *Arcady Dairy Feed.* Ingredients as stated by manufacturer, "Malt sprouts, brewers' dried grains, cottonseed meal, ground and bolted clipped oat by-product, ground and bolted screenings, salt, corn, gluten." Guaranteed to contain *18* percent crude protein, but failed by one and one-third percent to fulfill guaranty.

E. W. BAILEY & Co., Swanton, Vt. E. W. Bailey & Co., Montpelier; Half Century Store, Randolph; F. M. Sherman & Son, Newport; Frank Adams & Co., Bellows Falls. *Pennant Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product (oat hulls, oat middlings, oat shorts)." Guaranteed to contain *10* percent crude protein, but failed by two-thirds of one percent to fulfill guaranty.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Dairy Feed.* Ingredients as stated by manufacturer, "Old process linseed meal, dried brewers' grains, dried beet pulp, gluten feed, hominy, wheat middlings, wheat flour, wheat bran and salt." Guaranteed to contain *22* percent crude protein, but failed by three-fourths of one percent to fulfill guaranty.

[NOTE—Inability to secure cottonseed meal made it practically impossible to make a full 22 percent mixture. Cottonseed meal under normal conditions is an ingredient of these goods].

CHAPIN & Co., Hammond, Ind. E. M. Bixby & Son, Poultney; J. M. Burdick, Wallingford; R. L. Clark, Barre; Berry & Jones, Montpelier; W. B. Johnson & Son, Essex Junction; J. G. Turnbull Co., Orleans; C. M. McFarland & Son, Barton; F. H. Robinson, Chester Depot; E. Crosby & Co., Brattleboro. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, wheat bran, brewers' grains and salt." Guaranteed to contain *26* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. H. W. Myers & Co., Bennington; C. F. Wright, Bellows Falls. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, cocoa shell meal, clipped oat by-product, molasses and 0.5 percent salt." Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. Valley Grain Co., Brattleboro. F. M. Sherman & Son, Newport. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, clipped oat by-product, molasses and a small percentage of salt." Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. F. M. Sherman & Son, Newport; A. W. Washburn, Bethel. *Clover Leaf Dairy.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltze, ground grain screenings, cocoa shell meal, clipped oat by-product, molasses and a small percentage of salt." Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. H. P. Munson Estate, Morrisville; W. L. Ware & Co., Chester; R. L. Clark, Barre; A. W. Washburn, Bethel. *Wirth-*

more Balanced Ration for Milch Cows. Ingredients as stated by manufacturer, "Cottonseed meal, linseed meal, gluten feed, distillers' grains, bran, malt sprouts, hominy or corn meal, and 0.75 percent salt." Guaranteed to contain *25.5* percent crude protein, but failed by nearly one percent to fulfill guaranty.

CHAS. M. COX CO., Boston, Mass. W. L. Ware & Co., Chester; City Feed Co., St. Albans; W. B. Johnson & Son, Essex Junction; Berry & Jones, Montpelier; R. L. Clark, Barre; A. W. Washburn, Bethel; H. P. Munson Estate, Morrisville. *Wirthmore Stock Feed.* Ingredients as stated by manufacturer, "Ground barley, ground oats, ground hominy meal, ground corn, oatmeal mill by-products (oat middlings, oat shorts and oat hulls) and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

E. CROSBY & CO., Brattleboro, Vt. J. W. Jones Co., Burlington; St. Johnsbury Grain Co., St. Johnsbury; E. Crosby & Co., Brattleboro. *Crosby's Quality Feed Ready Ration.* Ingredients as stated by manufacturer, "Distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein, but failed by two-thirds of one percent to fulfill guaranty.

E. CROSBY & CO., Brattleboro, Vt. E. H. Mason, Randolph; Cunningham & Doubleday, St. Albans. *Crosby's Special Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn meal, hominy feed, brewers' dried grains, oatmeal mill by-products (oat shorts, oat hulls, oat middlings) and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

E. CROSBY & CO., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Quality Stock Food.* Ingredients as stated by manufacturer. "Ground barley, ground hominy feed, ground oats, oat feed (oat hulls, oat shorts, oat middlings)." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. E. T. Seabury Estate, Waterbury. *Dewey's Ready Ration.* Ingredients as stated by manufacturer, "Eagle distillers' dried grains, linseed oil meal, cottonseed meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

DEWEY BROS. CO., Blanchester, O. H. L. Baker, Springfield. *Dewey's Stock Feed.* Ingredients as stated by manufacturer, "Hominy feed, wheat and rye middlings, linseed oil meal, cottonseed meal, oat feed (oat middlings, oat hulls and oat shorts), and 0.5 percent salt." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

ELMORE MILLING CO., Oneonta, N. Y. S. Sherman & Son, Inc., Poultney; A. D. Pease, Burlington. *Elmore Milk Grains.* Ingredients as stated by manufacturer, "Corn distillers' dried grains, old process linseed meal, cottonseed meal, corn gluten feed, hominy meal, choice wheat bran, malt sprouts, dried brewers' grains, a little fine table salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. E. Lane & Sons, Newport. *Lucky Oat Feed.* Ingredients as stated by manufacturer, "Oats, corn, hominy feed." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

D. H. GRANDIN MILLING CO., Jamestown, N. Y. Davis Feed Co., Rutland; E. C. Crosby, Danby; F. H. Robinson, Chester Depot; C. F. Wright, Bellows Falls. *Grandin's Stock Feed.* Ingredients as stated by manufacturer, "Hominy feed, oatmeal mill by-products, oat middlings, hulls and shorts and salt." (Illegal label). Guaranteed to contain *8.5* percent crude protein; guaranty fulfilled.

H. O. CO., Buffalo, N. Y. Cunningham & Doubleday, St. Albans. *H. O. Co.'s Algrane Milk Feed.* Ingredients as stated by manufacturer, "Oat hulls, middlings, corn meal, oat shorts, corn gluten feed, ground corn, ground oats, ground grain screenings, molasses and 0.5 percent salt." Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

INDIANA MILLING CO., Terre Haute, Ind. E. Crosby & Co., Brattleboro. *Holstein Feed.* Ingredients as stated by manufacturer, "Wheat bran with ground screenings not exceeding mill-run, cob meal." Guaranteed to contain *12* percent crude protein, but failed by two and one-fourth percent to fulfill guaranty.

INDIANA MILLING Co., Terre Haute, Ind. W. B. Johnson & Son, Essex Junction. *Sterling Feed.* Ingredients as stated by manufacturer, "Wheat bran with ground screenings not exceeding mill-run, ground corn and cob." Guaranteed to contain *10* percent crude protein, but failed by one-half percent to fulfill guaranty.

INTERNATIONAL SUGAR FEED Co., Minneapolis, Minn. H. C. Skeels & Co., Swanton. *Climax Dairy Feed.* Ingredients as stated by manufacturer, "Corn meal, molasses, clipped oat by-product, ground recleaned grain screenings, salt." Guaranteed to contain *12.5* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. N. N. Morse & Sons, Randolph; S. P. Curtis & Son, Rutland; Frank Adams & Co., Bellows Falls. *Larro-Feed-Ready Ration for Dairy Cows.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, dried distillers' grains (mainly from corn), dried beet pulp, standard wheat bran, standard wheat middlings and 0.75 percent salt. Wheat bran and and wheat middlings may contain ground screenings not exceeding mill-run." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

A. H. MCLEOD MILLING Co., St. Johnsbury, Vt. A. H. McLeod Milling Co., St. Johnsbury; Corner Store, Hyde Park. *Brooks' Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, corn bran, ground oats, oat middlings, oat hulls, gluten feed." Guaranteed to contain *10* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

MOLASSINE Co., Boston, Mass. Kempton Mills, Barre. *Molassine Meal.* Ingredients as stated by manufacturer, "Molasses and cooked sphagnum." Guaranteed to contain 7 percent crude protein; guaranty fulfilled.

NOWAK MILLING CORPORATION, Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Justice Stock Feed.* Ingredients as stated by manufacturer, "Ground oats, corn feed meal, wheat middlings, oat middlings, oat hulls, clipped oat by-product, ground grain screenings, 0.75 percent salt." Guaranteed to contain *10* percent crude protein, but failed by nearly one and one-half percent to fulfill guaranty.

OSWEGO MILLING Co., Oswego, N. Y. Lapelle Poultry Food Co., Swanton; S. P. Curtis & Son, Rutland. *Stevens' Dairy Ration.* Ingredients as stated by manufacturer, "Oil meal, cottonseed meal, winter wheat bran, corn gluten feed, cocoanut oil meal, pea meal, distillers' grains (corn and barley), brewers' dried grains, ground barley, wheat middlings, hominy meal, corn ground meal, buckwheat middlings, corn meal, salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. Davis Feed Co., Rutland; N. N. Morse & Sons, Randolph. *Iowa Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn meal, hominy feed, brewers' dried grains, oatmeal mill by-products (oat shorts, oat hulls, oat middlings), and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Adams & Davis Co., Chester. *Buckeye Feed.* Ingredients as stated by manufacturer, "Wheat mixed feed, ground screenings not exceeding mill-run and rye shorts." Guaranteed to contain *15.5* percent crude protein, but failed by more than one-half percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. W. B. Johnson & Son, Essex Junction; E. M. Bixby & Son, Poultney; J. M. Burdick, Wallingford; E. H. Mason, Randolph; E. E. Harris & Co., Morrisville; E. Crosby & Co., Brattleboro; F. H. Robinson, Chester Depot; E. Lane & Son, Newport; E. T. & H. K. Ide, St. Johnsbury; City Feed Co., St. Albans; E. W. Bailey & Co., Montpelier; R. L. Clark, Barre. *Schumaker's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground barley, hominy feed, wheat flour, wheat middlings with screenings not exceeding mill-run, cottonseed meal, ground puffed rice, ground puffed wheat, oatmeal mill by-products (oat middlings, hulls, shorts), 0.5 percent salt." A varient of this included "kafir corn." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., INC., Buffalo, N. Y. W. L. Ware & Co., Chester; H. A. Slayton & Co., Morrisville; Burditt Bros., Rutland. *Purina Cow-Chow Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, gluten

feed, brewers' dried grains, molasses, ground alfalfa and one percent salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

RALSTON-PURINA CO., INC., St. Louis, Mo. W. L. Ware & Co., Chester. *Purina Feed with Molasses.* Ingredients as stated by manufacturer, "Cracked corn, whole oats, ground alfalfa, molasses and one percent salt." Guaranteed to contain *9.3* percent crude protein; guaranty fulfilled.

RALSTON-PURINA CO., INC., Buffalo, N. Y. A. H. McLeod Milling Co., St. Johnsbury. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

ST. ALBANS GRAIN CO., St. Albans, Vt. City Feed Co., St. Albans. *Farmers' Favorite.* Ingredients as stated by manufacturer, "Cottonseed meal, Buffalo gluten feed, malt sprouts, distillers' grains, bran, hominy or corn meal, linseed meal and 0.75 percent salt." Guaranteed to contain *25.5* percent crude protein; guaranty fulfilled.

DAVID STOTT MILLING CO., INC., Detroit, Mich. H. C. Skeels & Co., Swanton. *Winner Feed.* Ingredients as stated by manufacturer, "Corn meal, oat screenings, oat hulls, salt." Guaranteed to contain *10.5* percent crude protein; guaranty fulfilled.

UBIKO MILLING CO., Cincinnati, O. E. T. & H. K. Ide, St. Johnsbury; Frank Adams & Co., Bellows Falls; Valley Grain Co., Brattleboro; Strong & Goddard, Hyde Park; H. A. Slayton & Co., Morrisville; Burditt Bros., Rutland; E. W. Bailey & Co., Montpelier; Kempton Mills, Barre; F. M. Sherman & Son, Newport. *Union Grains; Biles' Ready Ration.* Ingredients as stated by manufacturer, "Fourex corn distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, brewers' dried grains, barley malt sprouts, 0.5 percent fine table salt and nothing else." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

VERMONT CEREAL CO., Burlington, Vt. H. A. Slayton & Co., Morrisville. *Waumbeck Butter Fat Meal.* Ingredients as stated by manufacturer, "Cottonseed meal, old process linseed meal, low grade flour and nothing else." Guaranteed to contain *22.25* percent crude protein, but failed by three and one-fourth percent to fulfill guaranty.

VERMONT CEREAL CO., Burlington, Vt. Brewster River Milling Co., Jeffersonville. *Waumbeck Stable Stock Feed.* Ingredients as stated by manufacturer, "Corn meal, rye and oat middlings, oats and oat hulls." Guaranteed to contain *8.5* percent crude protein; guaranty fulfilled.

R. P. WEBSTER, Barton, Vt. R. P. Webster, Barton. *Ray's Ready Ration.* Ingredients as stated by manufacturer, "Distillers' grains, bran, malt sprouts, gluten, cottonseed meal, molasses feed, linseed oil meal, 0.5 percent salt." (Illegal label). Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

WESTERN GRAIN PRODUCTS CO., Hammond, Ind. J. G. Turnbull Co., Orleans; E. T. & H. K. Ide, St. Johnsbury; E. E. Harris & Co., Morrisville. *Hammond Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn distillers' grains, malt sprouts, ground clipped oat by-product, ground grain screenings, molasses and salt." Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

XTRA VIM MOLASSES FEED CO., Boston, Mass. N. N. Morse & Sons, Randolph; *Xtra Vim Molasses Feed.* Ingredients as stated by manufacturer, "Pure cane sugar molasses mixed with a small percentage of sphagnum moss." Guaranteed to contain *4.61* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

PROPRIETARY FEEDS

CALF

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. Davis Feed Co., Rutland; E. W. Bailey & Co., Montpelier; N. N. Morse & Sons, Randolph; W. B. Johnson & Son, Essex Junction; Adams & Davis Co., Chester; E. Crosby & Co., Brattleboro. *Blatchford's.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, blood flour, barley meal, ground beans and peas, rice polish, old process oil meal,

cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt." A varient omits the "blood meal." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Half Century Store, Randolph; W. B. Johnson & Son, Essex Junction; H. L. Baker, Springfield; E. E. Harris & Co., Morrisville. *Schumaker's.* Ingredients as stated by manufacturer, "Oatmeal, wheat meal, ground flaxseed, milk albumin, cottonseed meal and 0.5 percent bicarbonate of soda." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RYDE & Co., Chicago, Ill. N. N. Morse & Sons, Randolph; R. P. Webster, Barton; H. L. Baker, Springfield. *Ryde's Cream.* Ingredients as stated by manufacturer, "Ground flaxseed, wheat flour, locust bean meal, cottonseed meal, blood flour, beans and lentils, cocoa shell meat, fenugreek, anise and salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

PROPRIETARY FEEDS

POULTRY

ANIMAL MEAL, MEAT SCRAPS, ETC.

AMERICAN AGRICULTURAL CHEMICAL Co., New York, N. Y. H. L. Baker, Springfield. *Protox Pure Ground Meat Scraps.* Guaranteed to contain *55* percent crude protein; guaranty fulfilled.

BEACH SOAP Co., Lawrence, Mass. Frank Adams & Co., Bellows Falls. *Pure Ground Beef Scraps.* Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. W. L. Ware & Co., Chester. *Ground Beef Scraps.* Guaranteed to contain *43* percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. Adams & Davis Co., Chester. *Ground Beef Scraps.* Guaranteed to contain *48* percent crude protein; guaranty fulfilled.

BURLINGTON RENDERING Co., Burlington, Vt. E. W. Bailey & Co., Morrisville; Frank Adams & Co., Bellows Falls. *Burlington Poultry Food.* Ingredients as stated by manufacturer, "Cooked meat and bone scraps, animal products." Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Pure Beef Scraps.* Guaranteed to contain *45* percent crude protein, but failed by three and one-half percent to fulfill guaranty.

MASHES

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. H. L. Baker, Springfield; S. P. Curtis & Son, Rutland. *Blatchford's Fill the Basket Egg Mash.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, blood flour, barley meal, ground beans and peas, rice polish, old process oil meal, cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt, alfalfa, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum, powdered limestone." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. H. P. Munson Estate, Morrisville; H. L. Baker, Springfield; W. L. Ware & Co., Chester; George Shorey & Son, Lyndonville; City Feed Co., St. Albans; Berry & Jones, Montpelier. *Wirthmore.* Ingredients as stated by manufacturer, "Ground oats, ground barley, gluten feed, alfalfa meal, wheat bran, ground corn, choice fine ground beef scraps, fish meal, wheat middlings and about 0.75 percent salt." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. C. F. Wright, Bellows Falls. *H. O. Dry Mash.* Ingredients as stated by manufacturer, "Oat middlings, corn gluten feed, wheat middlings, rolled oats, alfalfa meal, ground corn, hominy feed, cracked wheat, wheat bran." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

HALES & EDWARDS Co., Chicago, Ill. J. W. Jones Co., Burlington. *Red Comb Meat Mash.* Ingredients as stated by manufacturer, "Oatmeal, oil meal, corn meal, meat scraps, bran, middlings, alfalfa, and not over 5 percent shell." Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

W. B. JOHNSON & SON, Essex Junction, Vt. W. B. Johnson & Son, Essex Junction. *Dry Mash.* Ingredients as stated by manufacturer; not stated. (Illegal). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

N. N. MORSE & SONS, Randolph, Vt. N. N. Morse & Sons, Randolph. *Dry Mash for Poultry.* Ingredients as stated by manufacturer, "Bran, ground oats, corn meal, alfalfa meal, linseed meal, wheat middlings, beef scraps, fish scraps, charcoal, salt." Guaranteed to contain *18* percent crude protein, but failed by nearly two and one-half percent to fulfill guaranty.

PARK & POLLARD Co., Boston, Mass. R. L. Clark, Barre; E. W. Bailey & Co., Montpelier; E. Crosby & Co., Brattleboro; F. H. Robinson, Chester Depot. *Lay or Bust Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn, wheat, oats, barley, kafir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp, calcium sulphate and salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. E. Harris & Co., Morrisville. *Lay or Bust Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn, wheat, oats, barley, kafir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp and salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. Strong & Goddard, Hyde Park. *Lay or Bust Dry Marsh.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn, wheat, oats, barley, kafir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp and salt." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. N. N. Morse & Sons, Randolph. *Tom Boy.* Ingredients as stated by manufacturer, "Meat, wheat, oatmeal, wheat middlings, milo maize, buckwheat, corn meal, barley, oat middlings, millet, gluten feed, kafir corn, alfalfa meal, hominy feed, wheat bran, oat germ meal, rock phosphate, salt, calcium carbonate and charcoal." Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. A. D. Pease, Burlington. *Schumaker's.* Ingredients as stated by manufacturer, "Meat scraps, oat meal, bran with ground screenings not exceeding mill-run, alfalfa, yellow hominy feed, corn gluten feed, ground grain screenings." Guaranteed to contain *17.5* percent crude protein; guaranty fulfilled.

SCRATCH FEEDS

ACME-EVANS Co., Indianapolis, Ind. E. T. & H. K. Ide, St. Johnsbury. *E. Z.* Ingredients as stated by manufacturer, "Wheat, corn, oats, sunflower seed, oyster shells, charcoal." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BUFFALO CEREAL Co., Buffalo, N. Y. Adams & Davis Co., Chester. Ingredients as stated by manufacturer. "Corn, oats, barley, buckwheat, kafir corn, peas, sunflower seed, wheat." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Chicken Feed.* Ingredients not stated by manufacturer. (Illegal). Unguaranteed. Contained 11.3 percent crude protein.

CHAS. M. COX Co., Boston, Mass. Berry & Jones, Montpelier; R. L. Clark, Barre. *Wirthmore.* Ingredients as stated by manufacturer, "Wheat, kafir corn, sunflower seed, buckwheat, oats, barley, cracked corn, milo maize." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Pure.* Ingredients as stated by manufacturer, "Corn, wheat, rye, barley, oats, kafir corn, buckwheat, sunflower seed, and oil cake." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CUTLER Co., North Wilbraham, Mass. *Valley King.* Ingredients as stated by manufacturer; not stated. (Illegal). Guaranteed to contain *10* per cent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. H. P. Munson Estate, Morrisville. *Pine Tree.* Ingredients as stated by manufacturer, "Corn, wheat, buckwheat, barley, oats, kafir corn, sunflower seed." Guaranteed to contain *10* per cent crude protein; guaranty fulfilled.

ELMORE MILLING Co., Oneonta, N. Y. F. H. Robinson, Chester Depot. *Elmore.* Ingredients as stated by manufacturer, "Cracked corn, kafir corn, wheat, barley, buckwheat grains". Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. O. Co. MILLS, Buffalo, N. Y. C. F. Wright, Bellows Falls. *H. O. Algrane.* Ingredients as stated by manufacturer, "Wheat, oats, kafir corn, buckwheat, wheat screenings, cracked corn, milo maize, sunflower seed, hulled oats, cracked peas, barley." Guaranteed to contain *11* percent crude protein, but failed by one percent to fulfill guaranty.

LAPELLE POULTRY FOOD Co., Swanton, Vt. E. E. Harris & Co., Morrisville. *Pontiac.* Ingredients as stated by manufacturer, "Cracked corn, barley, wheat, buckwheat, oats, kafir corn, milo maize." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. Burditt Bros., Rutland; E. W. Bailey & Co., Montpelier. *Red Ribbon.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, oats, kafir corn, milo and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. Half Century Store, Randolph; F. H. Robinson, Chester Depot; E. W. Bailey & Co., Montpelier; E. Crosby & Co., Brattleboro; Strong & Goddard, Hyde Park. *Screened.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, oats, kafir corn, milo and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURINA MILLS, Buffalo, N. Y. Burditt Bros., Rutland. *Purina.* Ingredients as stated, by manufacturer, "Wheat, corn, barley, kafir, milo maize, sunflower seed." Guaranteed to contain *11* percent crude protein, but failed by nearly one percent to fulfill guaranty.

PURITY OATS Co., Davenport, Ia. N. N. Morse & Sons, Randolph; F. M. Sherman & Son, Newport. *Tom Boy.* Ingredients as stated by manufacturer, "Cracked corn, wheat, hulled oats, kafir corn or milo maize, barley, recleaned wheat screenings, buckwheat and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Corner Store, Hyde Park; A. D. Pease, Burlington; E. E. Harris & Co., Morrisville; H. L. Baker, Springfield; Valley Grain Co., Brattleboro. *Schumaker's.* Ingredients as stated by manufacturer, "Whole wheat, whole barley, cracked Indian corn, whole kafir corn, whole buckwheat, sunflower seeds." Guaranteed to contain *10* per cent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Burditt Bros., Rutland. *Protena.* Ingredients as stated by manufacturer, "Corn, wheat, barley, sunflower seed, kafir corn, milo maize." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHICK FEEDS, ETC.

CHAS. M. COX Co., Boston, Mass. W. L. Ware & Co., Chester. *Wirthmore Gritless Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, yellow corn, peas, kafir corn, milo maize, white corn and hulled oats." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. R. L. Clark, Barre. *Wirthmore Gritless Intermediate Chick Feed.* Ingredients as stated by manufacturer, "Cracked white corn, cracked yellow corn, wheat, kafir corn, buckwheat and peas." Guaranteed to contain *11* percent crude protein, but failed by three-fourths of one percent to fulfill guaranty.

JOHN C. DOW Co., Boston, Mass. W. L. Ware & Co., Chester. *Dow's Favorite Poultry Meal.* Ingredients as stated by manufacturer; not stated. (Illegal). Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

HALES & EDWARDS Co., Chicago, Ill. J. W. Jones Co., Burlington. *Red Comb Poultry Feed.* Ingredients as stated by manufacturer, "Wheat, cracked corn, kafir, barley, oats, sunflower seed, buckwheat." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. W. Bailey & Co., Montpelier; E. E. Harris & Co., Morrisville. *P. & P. Growing Feed.* Ingredients as stated by manufacturer, "Ground corn, wheat, barley, oats, meat, bone, alfalfa, kafir corn, wheat bran, wheat middlings, buckwheat, beet pulp, calcium carbonate and salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. W. Bailey & Co., Montpelier. *Intermediate Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, oats, millet, kafir corn and milo." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. W. Bailey & Co., Montpelier. *Red Ribbon Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, cracked wheat, cracked oats, kafir corn, milo maize and whole millet seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. W. Bailey & Co., Montpelier, *Gritless Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir corn, milo, whole millet seed, oats and shredded fish." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. W. Bailey & Co., Montpelier. *Baby Buster Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir, milo, whole millet seed, oats and shredded fish." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Kempton Mills, Barre. *Quaker Chick Feed.* Ingredients as stated by manufacturer, "Cracked wheat, cracked kafir corn, cracked Indian corn, whole millet seed, oat meal, wild buckwheat with not to exceed 0.5 percent foul seed and one percent charcoal." Guaranteed to contain *10* percent crude protein, guaranty fulfilled.

RALSTON-PURINA Co., INC., St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, bran, corn, salt, alfalfa meal, linseed meal, meat, charcoal." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. J. W. Jones Co., Burlington. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, bran, corn, salt, alfalfa meal, linseed meal, meat, charcoal." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

MISCELLANEOUS

PROVENDER

E. W. BAILEY & Co., Montpelier, Vt. E. W. Bailey & Co., Montpelier; R. L. Clark, Barre; Half Century Store, Randolph. ————. Contained *9.9* percent crude protein.

BUFFALO CEREAL Co., Buffalo, N. Y. Adams & Davis Co., Chester. ————. Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *No. 1.* Contained *10.5* percent crude protein.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *No. 2.* Contained *10.8* percent crude protein.

E. T. & H. K. IDE, St. Johnsbury, Vt. E. T. & H. K. Ide, St. Johnsbury. ————. Contained *10.3* percent crude protein.

KEMPTON MILLS, Barre, Vt. Kempton Mills, Barre. ————. Contained *10.3* percent crude protein.

LAPELLE POULTRY FOOD Co., Swanton, Vt. Lapelle Poultry Food Co., Swanton. ————. Contained *9.6* percent crude protein.

A. D. PEASE, Burlington, Vt. A. D. Pease, Burlington. *No.1.* Contained *11.4* percent crude protein.

A. D. PEASE, Burlington, Vt. A. D. Pease, Burlington. *No. 2.* Contained *12.3* percent crude protein.

TIOGA MILL & ELEVATOR CO., Waverly, N. Y. F. A. Sheldon, Rupert. *Derby.* Guaranteed to contain *9.25* percent crude protein; guaranty fulfilled.

CORN MEAL

ADAMS & DAVIS CO., Chester, Vt. Adams & Davis Co., Chester. ————. Contains *9.2* percent crude protein.

ADAMS & DAVIS CO., Chester, Vt. Adams & Davis Co., Chester. ————. Contains *9.6* percent crude protein.

E. W. BAILEY & CO., Montpelier, Vt. Half Century Store, Randolph; R. L. Clark, Barre; Strong & Goddard, Hyde Park; E. E. Harris & Co., Morrisville; E. W. Bailey & Co., Montpelier. ————. Contains *9.9* percent crude protein.

BURLINGTON FLOURING CO., Burlington, Vt. A. D. Pease, Burlington. ————. Contains *9.2* percent crude protein.

BURLINGTON FLOURING CO., Burlington, Vt. Burlington Flouring Co., Burlington. ————. Contains *9.7* percent crude protein.

BURLINGTON FLOURING CO., Burlington, Vt. Burlington Flouring Co., Burlington. *Cracked Corn.* Contains *9.1* percent crude protein.

E. CROSBY & CO., Brattleboro, Vt. E. Crosby & Co., Brattleboro. ————. Contains *9.4* percent crude protein.

KEMPTON MILLS, Barre, Vt. Kempton Mills, Barre. ————. Contains *9.6* percent crude protein.

ST. ALBANS GRAIN CO., St. Albans, Vt. City Feed Co., St. Albans. ————. Contains *10.1* percent crude protein.

H. A. SLAYTON & CO., Morrisville, Vt. H. A. Slayton & Co., Morrisville. ————. Contains *9.2* percent crude protein.

TIOGA MILL & ELEVATOR CO., Waverly, N. Y. F. A. Sheldon, Rupert. ————. Guaranteed to contain *9.2* percent crude protein; guaranty fulfilled.

GROUND OATS

ADAMS & DAVIS, Chester, Vt. Adams & Davis, Chester. ————. Contains *11.4* percent crude protein.

ADAMS & DAVIS CO., Chester, Vt. Adams & Davis Co., Chester. ————. Contains *12.3* percent crude protein.

E. W. BAILEY & CO., Montpelier, Vt. E. W. Bailey & Co., Montpelier; R. L. Clark, Barre; Half Century Store, Randolph. ————. Contains *12.1* percent crude protein.

E. W. BAILEY & CO., Montpelier, Vt. E. W. Bailey & Co., Montpelier; R. L. Clark, Barre. Contains *11.4* percent crude protein.

BREWSTER RIVER MILLING CO., Jeffersonville, Vt. Brewster River Milling Co., Jeffersonville. ————. Contains *12.1* percent crude protein.

BURLINGTON FLOURING CO., Burlington, Vt. Burlington Flouring Co., Burlington. *Rolled Oats.* Contains *12.4* percent crude protein.

BURLINGTON FLOURING CO., Burlington, Vt. Burlington Flouring Co., Burlington. ————. Contains *12* percent crude protein.

E. CROSBY & CO., Brattleboro, Vt. Half Century Store, Randolph. ————. Contains *11.4* percent crude protein.

H. N. GRAY, Cambridge, Vt. H. N. Gray, Cambridge. Contains *12.7* percent crude protein.

H. A. SLAYTON & CO., Morrisville, Vt. H. A. Slayton & Co., Morrisville. ————. Contains *12.9* percent crude protein.

TIOGA MILL & ELEVATOR CO., Waverly, N. Y. F. A. Sheldon, Rupert. ————. Contains *12.7* percent crude protein.

RYE PRODUCTS

BARBER & BENNETT, Albany, N. Y. S. P. Curtis & Son, Rutland. *Fort Orange Rye Feed.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BOUTWELL MILLING & GRAIN CO., Troy, N. Y. Burditt Bros., Rutland; F. H. Robinson, Chester Depot. *Boutwell's Rye Feed* (rye feed with ground screenings not exceeding mill-run). Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

BOUTWELL MILLING & GRAIN CO., Troy, N. Y. J. M. Burdick, Wallingford. *Rye Feed.* Guaranteed to contain *12.5* percent crude protein; guaranty fulfilled.

E. CROSBY & CO., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Rye Meal.* (Unguaranteed). Contained *10* percent crude protein.

QUAKER OATS CO., Chicago, Ill. E. W. Bailey & Co., Montpelier. *F. T. Rye Meal.* (Unguaranteed). Contained *14.1* percent crude protein.

WASHBURN-CROSBY CO., Minneapolis, Minn. E. Crosby & Co., Brattleboro. *Pure Rye Middlings.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

DISCUSSION OF THE RESULTS OF INSPECTION

There were taken 44 samples of the high protein by-products (cottonseed and linseed meals, gluten feeds, distillers' and brewers' dried grains), 27 samples of low protein products other than wheat offals (hominy feed, dried beet pulp, alfalfa meal, etc.), 122 samples of wheat offals (brans, middlings, mixed feeds, red dog flour) and 134 samples of proprietary brands, ready mixed rations for horses, cattle and poultry.

The writer regretted that he was not able to announce a satisfactory outcome in 1916; and he now is sorry to say that he must needs be similarly pessimistic as to the present situation, which is distinctly disappointing. A larger proportion of the feeding stuffs than usual has failed to measure up to the promises made in their behalf. The following tabulation sets forth the situation for the current inspection in concise form; and the annexed discussion goes into details.

	Number of analytical samples	Number of different brands	Protein guaranties range from	Protein contents range from	Guaranty fulfilled within tolerance figures	Guaranty not fulfilled	Unguaranteed
Cottonseed meals	13	13	41 to 36	43.4 to 34.9	5	8	..
Cottonseed feed	1	1	20.6	21.1	1	..	..
Linseed meals	7	6	34 to 30	35.5 to 29.9	7	..	..
Gluten feeds, etc.	9	9	25 to 17	26.7 to 19.5	8	1	..
Dried distillers' grains	8	8	31 to 24	31.6 to 23.8	5	3	..
Dried brewers' grains	6	5	27.2 to 20	29.4 to 20.1	6	..	..
Wheat offals	122	118	18.7 to 12	19.9 to 12.3	109	12	1
Wheat brans	41	39	17 to 12	16.9 to 12.3	39	1	1
Wheat middlings	33	30	18.7 to 12.5	19.9 to 14.7	26	7	1
Wheat mixed feeds	41	41	17.5 to 12.7	18.9 to 14.5	38	3	..
Red dog flours	7	7	16.8 to 14	19.1 to 14	6	1	..
Hominy feeds	10	10	11.3 to 9	11.8 to 10.3	10	..	..
Dried beet pulps	3	2	8	9.3 to 9	3	..	..
Alfalfa meals	14	12	16.6 to 12	17.4 to 13.4	11	1	2
Proprietary feeds	90	..	55 to 4.6	57.9 to 4.3	..	..	..
Dairy, horse, stock	40	39	25.5 to 4.6	26.9 to 4.3	32	9	..
High protein	13	11	25.5 to 20	26.9 to 19.6	12	1	..
Medium protein	8	8	18 to 12.5	19.8 to 13.1	6	2	..
Low protein	20	20	12 to 4.6	16.3 to 4.3	14	6	..
Calf	3	3	25 to 18	25.4 to 19.8	3	..	..
Poultry	45	43	55 to 10	57.9 to 41.6	38	6	1
Animal meals	6	6	55 to 40	57.9 to 41.6	5	1	..
Mashes	11	9	19 to 15	21.8 to 15.2	10	1	..
Scratch feeds	16	16	11 to 10	11.4 to 10.1	13	2	1
Chick feeds	12	12	30 to 10	33.4 to 10.2	10	2	..
Miscellaneous	38			14.1 to 5.3	..	..	..
Provender	10			12.3 to 9	..	..	..
Corn meal	11			10.1 to 9	..	..	..
Ground oats	9			12.9 to 11.4	..	..	..
Rye products	6			14.1 to 10	..	..	..
Miscellany	2			11.4 to 5.3	..	..	..

The situation is yet more concisely set forth as follows:

Cottonseed meals. Nearly two-thirds of the cottonseed meal samples were not what they were represented to be in respect to their protein contents.

Dried distillers' grains. Nearly two-fifths of the distillers' dried grains were similarly deficient.

Wheat feeds. One-tenth of the wheat feeds carried less protein than they were said to contain. The middlings were especially deficient.

Proprietary feeds. (*Dairy, horse, stock*). One-fifth of the brands were lacking in protein, that is to say they were poorer in this respect than they were said to be by their manufacturers.

Proprietary feeds. (*Poultry*). One-seventh of the brands were lacking in protein, poorer in this respect than they were said to be by their manufacturers.

The grand total. One in six of the brands offered for sale in the winter of 1916-17 was short of its protein promise. This outcome is identical with that found last year. It is as bad an outcome as has been found during the 20 years of feeding stuffs inspection. Vermont buyers of feeds pay higher prices than heretofore and get poorer goods.

In the following cases divergence between protein promise and fulfillment seems to be excessive.

F. W. Brodé & Co., Memphis, Tenn.
Dove Cottonseed Meal ....Guaranty 38.63%. Analysis 34.9%.

Buckeye Cotton Oil Co., Cincinnati, Ohio.
Buckeye Prime Cottonseed Meal,
Guaranty 38.62%. Analysis 35.8%.

C. L. Campbell & Co., Little Rock, Ark.
Camel Cottonseed Meal .....Guaranty 38.5% Analysis 3.62%.

C. L. Montgomery & Co., Memphis, Tenn.,
Canary Cottonseed Meal...Guaranty 38.63%. Analysis 35.8%.

C. L. Montgomery & Co., Memphis, Tenn.
Canary Extra Cottonseed Meal..Guaranty 41% Analysis 38.4%

J. E. Soper Co., Boston, Mass.
Pilgrim Cottonseed Meal ...Guaranty 38.5%. Analysis 36.4%.

J. E. Soper Co., Boston, Mass.
Pioneer Cottonseed Meal.....Guaranty 41%. Analysis 36.8%.

American Maize Products Co., New York, N. Y.
Cream of Corn Gluten Feed....Guaranty 24%. Analysis 22.1%

American Milling Co., Peoria, Ill.
Empire State Dairy Feed.....Guaranty 30%. Analysis 27.1%.

Ubiko Milling Co., Cincinnati, Ohio.
Fourex Distillers' Dried Grains,
Guaranty 31%. Analysis 28.7%

Somers & Co., San Francisco, Cal.
Red Star Alfalfa Meal.....Guaranty 16.6%. Analysis 14.8%.

Arcady Farms Milling Co., Chicago, Ill.
Arcady Dairy Feed .....Guaranty 18%. Analysis 16.7%.

E. W. Bailey & Co., Montpelier, Vt.
Pennant Stock Feed.....Guaranty 10%. Analysis 9.3%.

Indiana Milling Co., Terre Haute, Ind.
Holstein Feed .....Guaranty 12.1%. Analysis 9.8%.
Indiana Milling Co., Terre Haute, Ind.
Sterling Feed .....Guaranty 10%. Analysis 9.5%.
Nowak Milling Corporation, Buffalo, N. Y.
Justice Stock Feed.....Guaranty 10%. Analysis 8.4%
Vermont Cereal Co., Burlington, Vt.
Waumbeck Butter Fat Meal..Guaranty 22.25%. Analysis 19%.
Xtra Vim Molasses Feed Co., Boston, Mass.
Xtra Vim Molasses Feed....Guaranty 4.61%. Analysis 4.3%.
E. Crosby & Co., Brattleboro, Vt.
Crosby's Pure Beef Scraps...Guaranty 45%. Analysis 41.4%.
N. N. Morse & Sons, Randolph, Vt.
Dry Mash for Poultry.....Guaranty 18%. Analysis 15.6%.
H. O. Mills, Buffalo, N. Y.
H. O. Scratch Feed .....Guaranty 11%. Analysis 10.1%.
Chas. M. Cox Co., Boston, Mass.
Wirthmore Gritless Intermediate Chick Feed,
Guaranty 11%. Analysis 10.2%.

There were seven wheat offals which failed by considerable margins to make good their maker's protein guaranties. The facts are set forth in the tables on pages 17 to 25. In view of the fact that the Vermont law does not require that wheat offals be guaranteed it seems inadvisable specially to mention them at this point.

CONCERNING THE READY MIXED GOODS

These goods are widely advertised and widely used. Many of them are made from standard feeding stuffs; many contain material of low feeding value. Each package proclaims its contents, so that he who runs may read—if he will.

Let us compare the prices of the different sorts sold for the feeding of cattle, horses, etc.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	Approximate average selling price twelve months ago	Increase
High protein ..	11	20 to 26	24	$42.00	$34.50	$7.50
Medium protein	8	13 to 18	16	33.50	29.00	4.50
Low protein ...	20	5 to 12	10½	39.50	32.00	7.50

There is obviously no relationship between protein content and selling price; hence he who needs protein to balance his farm-grown

grains and roughages need not be deterred by price in choosing the higher rather than the lower grades since they cost on the average but $2.50 more.

Let us next compare the prices of the different sorts sold for the feeding of poultry.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	Approximate average selling price twelve months ago	Increase
Meat meals	6	40 to 55	40	$57.50	$57.00	$0.50
Mashes	9	15 to 19	16½	52.00	44.00	8.00
Scratch feeds	16	10 to 11	10	51.50	42.00	9.50
Chick, etc., feeds	12	10 to 30	13	51.50	44.00	7.50

Let us finally note the following statement of average guaranties and selling prices of concentrates which may prove of interest in this connection.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	Average selling price twelve months previous	Increase
High protein, 20 to 40%						
Cottonseed meal	13	36 to 41	38½	$46.50	$38.00	$ 8.50
Cottonseed feed	1	21	21	41.00	....	....
Linseed meal	6	30 to 34	32	49.00	42.00	7.00
Gluten feed	9	17 to 25	23	41.50	33.00	8.50
Distillers' dried grains	8	24 to 31	28	42.00	35.00	7.00
Brewers' dried grains	5	20 to 27	24	35.00	30.00	5.50
Medium protein, 15 to 20%						
Wheat bran	39	12 to 17	15	34.00	27.00	7.00
Wheat middlings	30	13 to 19	16	39.50	31.00	8.50
Wheat mixed feed	41	13 to 18	16	39.00	31.00	8.00
Low grade (red dog) flour	7	14 to 17	16	48.00	35.00	13.00
Low protein, 8 to 15%						
Hominy feed	10	9 to 11	10	44.50	32.00	12.50
Alfalfa meal	12	12 to 17	14	35.50	31.00	4.50
Dried beet pulp	2	8	8	34.00	29.00	5.00
Provender	10			44.00	....	....
Corn meal	11			44.50	....	....
Ground oats	9			43.50	....	....
Rye by-products	6			35.00	....	....

The prices for 1916 were those asked in January-April, those for the current inspection in December. Speaking broadly, the ready mixed foods cost from seven to eight dollars more in December, 1916 than they did in the preceding winter; and the staples from which they were made advanced in price quite as much or perhaps a shade

more. They were held later in the winter at yet higher prices and were hard to get at any price. The present situation is unprecedented.

Notwithstanding these changes in price it is still true that it is sometimes possible to buy standard concentrates and make home mixtures of a high protein content at some saving as compared with the purchase of ready mixed goods of the higher protein grade. This statement is based on calculations which involve the use of reasonable proportions of the ingredients claimed, sufficient in each case to meet the guaranty statements made by the manufacturers. However, as figures were quoted last December, taking into account the cost of mixing at home, the prices asked for these high protein rations were not exorbitant as compared with those asked for the several forms of crude stock.

The high protein ready-rations seem to be thoroughly desirable combinations and with rare exceptions high class ingredients are used in their construction. The molasses and stock feeds are of a different sort. Among the list of ingredients declared by the manufacturers of the high protein goods one finds but rarely the acknowledgment of the use of a manufacturing by-product of relatively inferior feeding value. It is quite otherwise with the lower grades. Among the molasses and stock feed statements one finds such ingredients as "ground grain screenings," "clipped oat by-product," "ground and bolted grain screenings," "recleaned grain screenings," "oat clippings," "flax plant by-product," "cooked sphagnum," "grain screenings," "oat meal by-products (oat middlings, oat hulls, oat shorts)," "ground recleaned grain screenings," "oat hulls," "cob meal," "screenings," "ground corn and cob." Yet the prices asked for goods which proclaim the carriage of such material is but little less per ton than those asked for higher graded goods; on the acreage $2.50 in the present inspection. The fact that materials like "oat clippings," "cob meal," "ground grain screenings," etc., are not offered as such on Vermont markets and that their commercial values are not known to the writer, prevents the calculations upon which was based the above statements as to the relative money values of ready mixed and home mixed high protein rations.

IV. CONCERNING ALFALFA AND SOY BEANS

By J. L. HILLS

INTRODUCTION

For almost a decade the annual feeding stuff inspection bulletin has been made the vehicle for the purveyal of an informational article dealing with feeding practice, following in this respect in the wake of the fertilizer control bulletins in which informational articles concerning fertilizers were issued for the first time in 1902. This practice is warranted by the somewhat wide latitude which is accorded the Station by the feeding stuffs law which permits it to include in its feeding stuffs inspection bulletins "such additional information in relation to the character, composition, value and use of such feeding stuffs as circumstances may advise." The feeding stuffs bulletins which have been of this character in the past have discussed the following matters:

1908. No. 138. The viability of weed seeds in feeding stuffs.
1909. No. 144. Concerning the manufacture and nature of feed; the economics of feed purchase; the formulation of grain rations; statement concerning feeding.
1910. No. 152. Principles and practice of stock feeding, including discussion of animal nutrition, feeding standards and sundry economic considerations, as well as a full glossary and tables displaying the several feeding standards, the average composition of roughages and concentrates, digestion coefficients and digestible ingredients and a "convenience table" giving the pounds of dry matter and digestible ingredients in various fodders and feeds.
1911. No. 158. Concerning feeding standards, being a review of the energy value scheme; the Minnesota station findings and the Scandinavian feed unit system; summer soiling suggestions.
1912. No. 164. Condimental feeds.
1913. No. 171. Concerning the Vermont hay crop.
1914. No. 180. Concerning feeding practice; including discussions of what the cow does with the feed she eats, how to balance a ration, advisable roughage to grow, advisable grain feeds to buy, suggestions as to profitable milk production, and balanced rations for hens.
1915. No. 189. Concerning the corn crop.
1916. No. 197. Concerning the oat crop.

It seemed advisable, since Vermont's three main crops, hay, corn and oats, have been discussed in former issues, to review this year two crops which are beginning to assume prominence in the State, concerning which there is none too much popular information among Vermont farmers, namely alfalfa and soy beans. The present article is the result of this determination. There is nothing whatever original about it. It represents simply a compilation. Several federal and state publications as well as some of the more recent books dealing with these

crops were used in its construction, especially Farmers' Bulletins 339 and 372 by Messrs. J. M. Westgate and C. V. Piper and "Alfalfa Farming in America," by the late Joseph E. Wing of Ohio. No attempt has been made exhaustively to cover the field but simply to make a somewhat fragmentary presentation of the subject, loose jointed and none too well built.

The writer has not hesitated to follow quite closely in some cases the language of Messrs. Westgate and Piper, the authors of Farmers' Bulletins 339 and 372. These gentlemen are experts; their opportunities for study of these crops have been a thousand times better than the writer's; their statements are public property; hence it seems eminently proper to draft them for this purpose. Their language has been abbreviated in many, expanded in some, altered in several places, and it has been adopted *verbatum et literatum* in a few cases. No quotation marks are used, this blanket acknowledgment being held to be sufficient to absolve the writer from changes of plagiarism.

The Station has twice printed matter concerning alfalfa in Bulletin 114 (1905), entitled "Alfalfa in Vermont," and the nineteenth report (1905-06), "Alfalfa Culture in Grand Isle County." It has made a few minor statements concerning soy beans twenty or more years ago (7th-10th reports, 1893-96).

ALFALFA

Alfalfa seems to have been "born" so to speak, in Central Asia whence it has spread throughout the arable world, it being a staple forage crop in every continent. Alfalfa is the oldest plant known cultivated solely for forage. It grew in southwestern Asia at least 500 years before Christ. It was introduced into Central and South America in the sixteenth century and some 60 years ago in California from Chili, whence its culture spread rapidly over the irrigated regions of the West, particularly in the more humid portions of the Great Plains area, and somewhat more slowly over the non-irrigated sections. It is now the main standby as a leguminous forage crop throughout this western region where many millions of acres are grown. Unsuccessful attempts were made at various times during the seventeenth to the nineteenth centuries to introduce it from Europe upon the Atlantic seaboard, although it has grown locally for many years, especially on limestone soils, in several eastern States. Its rapid extension throughout the East during the past decade indicates now that its special needs and idiosyncrasies are well understood, that its likelihood

of becoming an important factor in our agricultural operations is greatly enhanced.

In 1904, 56 Vermont farmers, 22 in the Champlain valley and 34 in other sections, reported as to their success in alfalfa growing, with results as follows: Permanent success i. e., where the crop had done well for four years and bade fair to continue to do well, 12; temporary success, i. e., one or two years' successful growth, 10; some crops looking well in November, 8; seeming success, 5; questionable outcome, 7; failure, 14. Among the testimonies of those who had achieved success were: "Grew several acres which did well for four or five years but were run out by native grasses"; "three acres on which for eight years two crops of two tons or more per acre have been harvested"; "three and one-half acres now badly run out with weeds"; "four acres which yielded two crops in 1904"; "three acres in excellent condition"; "three acres which have been an entire success"; "four acres seen in 1904 on which crop is a success and outlook good"; "four acres drilled with good success the first and fair success the second year."

Alfalfa is a deep- or tap-rooted, long lived herbaceous, leguminous forage plant. Its flowers are predominently violet, but may be yellow, blue, green or purple, clover-shaped and borne in compact clusters. Its seeds are kidney-shaped, small, and contained in small, spiral coiled pods. Its tap-root may extend downward 15 or more feet, reaching stores of plant food and moisture inaccessible to shallow-rooted crops.

Its world-wide distribution evidences its remarkable adaptability. In none of our States is its growth inhibited by climatic condition. The hardier strains can readily withstand our severe winters. In humid regions, however, soil and treatment must be right if it is to succeed. For example, a rainfall in excess of three feet annually is apt to be a detriment, since weeds and fungous diseases are more prevalent. Especial care is needed in areas not naturally suited to its growth to provide the favorable conditions required by the young plants.

A deep, fertile and well-drained soil, one which is rich in lime and is reasonably free from weeds, is needed. If any one of these essentials is lacking or is below par, failure is very apt to result. This is especially true in the East where at best the crop is grown with difficulty.

1. *A deep, permeable soil* should be chosen for the reason that alfalfa is naturally a deep-feeding plant. If it lacks depth the plant cannot utilize its deep-feeding root system and is less likely to withstand the inroads made by weeds. Yet its roots can penetrate rather

stiff clay soils and at times even those underlain with hardpan. Indeed, instances have been observed in eastern limestone sections where alfalfa has grown successfully on soils underlain at a depth of but 18 inches with limestone ledges.

2. *A fertile soil is needed.* Alfalfa, being a legume, because of the nodule-forming bacteria which grow within its root structures, can add nitrogen to the soil and thus increase its fertility. Since large yields draw heavily upon other forms of plant food, alfalfa usually requires as rich and as well-drained a soil as the farm affords. However, a successful crop will afford returns which justify the use of such land. There is risk, however, in selecting bottom lands for the reason that their drainage is inadequate and weed infestation is likely to ensue. It is usually better practice to sow the new crop on higher, rolling land and to secure the needed plant food by plowing under green manuring crops or by applying barnyard manure or commercial fertilizers.

(a) *Green-manure crops*[1] are especially adapted to increase the humus content of a soil; and such an increase is just what many soils require if alfalfa is to be raised upon them. Clover, soy beans and vetches may be used for this purpose. It is ordinarily best to follow the green-manure crop with some clean-culture crop before seeding to alfalfa, because the decaying herbage is apt to induce a soil acidity which is unfavorable to alfalfa growth.

(b) *Well-rotted barnyard manure* is usually found to be the most satisfactory fertilizer for a proposed alfalfa field. It not only supplies plant food and humus but in addition it helps to inoculate the soil. Fresh manure carries so many weed seeds that, if necessary to use it, the application should be made to the preceding crop. This will give time for the germinating weed seeds to be destroyed by cultivation. This is a most important point for the reason that alfalfa does not wage a winning warfare with weeds.

(c) *Commercial fertilizers* may be liberally used if barnyard manure is unavailable or green manuring inadvisable. They should be reasonably rich in phosphate acid, and potash (if obtainable), but carry little nitrogen. Kinds and amounts will naturally vary with soil and other conditions. Woods suggests 50 pounds nitrate of soda, 400 pounds acid phosphate and 250 pounds of muriate of potash—a 1-7-18 formula now impossible and doubtless too high in potash; VanSlyke, 60 pounds nitrate of soda, 125 pounds dried blood or cottonseed meal, 500 pounds acid phosphate and 400 pounds of muriate of potash—a

[1] See Vt. Sta. Bul. 135 dealing with "Green Manuring."

2-7-19 formula open to the same criticism as stated above—to be followed by an annual surface application of a ton or two of half rotted stable manure and of 50 pounds nitrate of soda, 300 pounds of acid phosphate and 150 pounds of muriate of potash—a 1½-9-16 formula, also impossible nowadays.

3. *A well-drained soil* is especially important. Alfalfa requires much more complete soil drainage than do most other field crops. Where the underdrains do not carry off the rainfall rapidly enough it is sometimes thought advisable to practice backfurrowing, leaving dead furrows at intervals of a rod or less[1].

Alfalfa may be killed by stream overflows. It will not withstand more than 24 hours of complete submergence or 48 hours of partial overflow while in full growth. During the winter, however, fields may remain under flowing water for two weeks without serious injury.

4. *A well-limed soil* is essential in alfalfa growing. No other forage crop requires so much lime in the soil. The so-called soil acidity must be neutralized and an excess of lime must be present for crop use. Soils that are strongly acid to a depth of two to three feet seldom give permanent success with alfalfa even if the surface is treated with lime. Alfalfa is most easily produced on limestone soils, yet these soils often require liming, since the rains tend to leach lime out of the soil surface layers. If ever a soil requires liming, it will require it for alfalfa. It is usually best applied during the season previous to sowing the crop, as this allows time for thorough incorporation into the soil. There are several forms on the market. As a general rule it is best to buy that form which will furnish the most actual lime for a given money outlay. Ground limestone is proving satisfactory in many sections of the State and is apt to be the cheapest and most satisfactory form in which to use lime. Under normal conditions a ton of ordinary lump or ground lime or two tons of limestone is usually applied to an acre.[2]

Vermont farmers contemplating the growth of alfalfa are advised to submit accurately taken samples of their soils to the Station for its free analysis which will indicate their lime requirements. They will then know just how much is needed and neither waste because of overusage or fail because of underusage.

5. *A weed-free soil* is absolutely essential, a *sine qua non*. Young alfalfa plants are weaklings and are easily killed by weeds during the

[1] See Vt. Sta. Bul. 173 on "The Principles of Drainage."
[2] See Vt. Sta. Bul. 160 concerning "Limes and Liming."

early stages of their growth; and for this reason it is vitally necessary that the land be as nearly weed-free as possible. This condition can be brought about by raising some cultivated crop for two or three seasons previous to planting alfalfa, or by seeding the land successively to crops which naturally prevent weed growth. If a weedy soil must be used, the land should be plowed several months before the alfalfa is seeded and the successive crops of germinating weeds destroyed by frequent harrowing. Weeds are especially harmful to spring-seeded alfalfa; hence mid-summer or late summer seeding should be practiced whenever possible.

CROPS WHICH MAY PRECEDE ALFALFA

The time of year that any given crop may be harvested and the land prepared for alfalfa is an important factor in choosing the precedent crop. Clean-culture crops, such as corn, are useful in ridding the land of weeds. A heavy application of manure may be used, trusting to thorough cultivation to destroy any weeds that may have been thus introduced. Of course corn cannot be harvested in time for the summer seeding of alfalfa. A green-manure crop, such as hairy vetch or common clover, may be seeded in the fall, cut for hay the following spring and the stubble plowed under in preparation for alfalfa.

When spring or early summer seeding is necessary, corn-stubble land may be disced and harrowed for alfalfa. A small-grain crop may also follow the clean-culture crop and immediately precede the alfalfa in sections where the stubble can be plowed under in time for its seeding. The objection to this method lies in the fact that the small grain crop may use up the soil moisture so that the alfalfa makes a weak growth. Sod or pasture land usually may be plowed in the spring and fitted for alfalfa for late summer seeding.

PREPARING THE SEED BED

Young alfalfa plants are so tender that the soil must needs be in excellent tilth at planting time, fine on top but thoroughly settled. The young taproot strikes down immediately and may be injured if it encounters a layer of loose dry soil at the bottom of the old furrow. About six weeks are required for plowed land to settle enough for seeding. It may be sufficient, however, with some soils that they be disced instead of plowed, since less time is required for the land to settle and the operation is much less expensive; but this procedure can hardly be

recommended for many Vermont soils. The preparation of the soil for alfalfa can hardly be overdone. One Massachusetts alfalfa grower some years ago harrowed his field 17 times before planting it; and he harvested a fine crop for several successive years.

Soil preparation should be uniformly good the whole piece over, for the reason that poorly prepared spots are apt to fail. These bare places form centers from which weeds may spread and ultimately destroy the whole stand. Summer fallowing proves effective as a means of ridding the ground of weeds.

SELECTION OF SEED

Seed selection, its original source, viability and impurities are important matters to which should be accorded much attention. Southern-grown seed should not be used in the North on account of winter killing. One should choose seed grown in a region of about one's own latitude. California alfalfa seed, grown under conditions when irrigation occurs, does not do well as a rule in Vermont.

The demand for alfalfa seed has for some time exceeded the supply and there is little old seed offered. However, samples five to seven years old lose but little of their germinating power. The greatest care should be taken to get seed free from dangerous weeds.[1] Samples should be secured the winter before the seed is to be sown. It is often impossible in the spring just before seeding to purchase seed from the same lot after the delay incident to making home germination tests and receiving purity tests from the Experiment Station. Some seed firms book orders for certain lots of seed "subject to satisfactory germination and purity tests." This practice will doubtless become general when there is a sufficient demand for it on the part of the farmer.

VARIETIES

There is little real structural difference between the more modern resistant varieties and the ordinary home-grown sort. The *Turkestan* seems adapted to semi-arid regions; the *Grimm*, a hardy variety—perhaps identical with sand lucern—to northern latitudes; *Arabian* to the far Southwest.

There are several strains of alfalfa characterized by their hardiness and general ability to withstand conditions which are too severe for ordinary alfalfa, the most conspicuous examples being the commer-

[1] See Vt. Sta. Bul. 200 concerning "Weed Seeds in Alfalfa Seed."

cial sand lucern and an acclimated strain of sand lucern called Grimm alfalfa.

The sand lucern has been grown for many years and is adapted to the colder and drier sections of the country. It seems particularly fitted to withstand the cold northern winters where ordinary alfalfa is likely to winterkill. Its yields are always satisfactory, but it tends to lodge.

The Grimm alfalfa, which has been grown for many years in the West with excellent success, was brought to Minnesota from Germany in 1857 by a farmer named Grimm. It is claimed that it has attained increased hardiness since its introduction into this country. Grimm seed is often called for in this section of the country, but it is a question whether as a matter of fact one pound in five, perhaps one in ten, of the so-called Grimm seed as sold on our markets is true to name.

Siberian alfalfa, often called Yellow and Sickle alfalfa, grows wild in Siberia and northern Europe. It differs from common alfalfa in having a branching root system, a spreading habit of growth and yellow flowers. Its yield is low.

Sand lucern and Grimm alfalfa are midway between common alfalfa and Siberian alfalfa in having a medium branching root system and showing a tendency to spread. Their yields are good. On account of this root branching habit, Grimm alfalfa is less subject to injury from heaving than are other varieties.

SEEDING

Midsummer or late summer seeding is usually best in the East. Sowing should be done as far in advance as possible of what promises to be the most trying season for the young plants. Spring or early summer seeding is done in Minnesota, Wisconsin and the Dakotas, where stands other than those seeded in spring or early summer are very apt to winterkill.

Midsummer's weeds constitute the worst danger of the young stands in New England, unless it be winterkilling. Consequently midsummer or late summer seeding should be practiced. An early-maturing crop may be removed in time for seeding, the danger from weeds is avoided, and ample time is afforded wherein to make a strong growth to resist winterkilling and the heaving of the ground in the spring. The large growth which may occur during the early fall also enables the crop to make a rapid early growth the following spring. On this account the alfalfa is the better able to resist the inroads of weeds than

if it had been seeded the previous fall or during the same spring. A fair yield of hay is secured the season after seeding, and the use of the land is not lost for a year, as is likely to be the case with spring or fall seeding.

The seed should be covered and not sown on the surface. It may be planted in any way most convenient; with a drill or seeded broadcast with a hand or wheelbarrow seeder, or by hand. It is well to sow half of it one way across the field and the other half at right angles to the first sowing.

Soil conditions govern the depth of planting. A three-fourths to one inch covering is usually sufficient on clay soils and an inch and a half on sandy soils in order to insure sufficient moisture for germination. Whenever broadcasted, a light harrow, weeder, or brush should be used to cover the seed. A light soil may be rolled, but this procedure is not usually advisable. A smaller quantity of seed is used when it is drilled than when broadcasted. If a grain drill is used, the amount seeded may be regulated by the use of leather thongs to reduce the feed. Special alfalfa and grass seed drills are now made by several manufacturers.

Twenty pounds per acre is the amount usually recommended, to be increased where the danger from weeds is serious and it is necessary that the plants cover the ground from the start in order to prevent the weeds from becoming established. At this rate, each square foot would receive 100 seeds. This is not too many, however, in view of the fact that a considerable number of the seeds fail to grow, and that the young plants are forced to encounter many difficulties.

USE OF A NURSE CROP

A nurse crop usually proves disastrous, often resulting in the complete destruction of the stand. In sections where it can be used alfalfa usually succeeds in spite of rather than by reason of the nurse. A very light seeding of small grain, preferably barley, as a nurse crop is sometimes used in sandy soils to prevent blowing and consequent injuring, especially if the alfalfa is spring sown.

In all cases the nurse crop, if used, should be cut as soon as it shows signs of injuring the alfalfa plants. Several alfalfa failures in its earlier days in Vermont were rightly ascribed to the sacrifice of the nursling in the interests of the nurse. The would-be alfalfa grower

could not resist the temptation of letting the oats or barley stand until ripe.

Alfalfa is rarely grown mixed with clover or grasses; partly because it grows better alone, fully occupying the ground, but chiefly because it makes a quicker growth than they do and must be cut early and often. Where it succeeds its total yield of digestible nutrients is greater than that of either clover or grass. Four or five tons of cured hay per acre is not uncommon in Central New York.

INOCULATION

It is now quite generally understood by farmers that alfalfa, like all leguminous plants, succeeds only if the root hairs are infected by certain species of soil bacteria which cause the formation on these hairs of small excrescences known as "nodules." Through the joint activity of the bacteria and the host plant, nitrogen is "fixed" and made available to plant uses. If these nodule-producing organisms are not present in the soil, no nodules are formed, no nitrogen is gathered, and the crop is sickly, weak, yellow and starved. If they are present in sufficient quantities and are active, nodules are formed, nitrogen is gathered, and, other conditions being favorable, the crop succeeds.

Few farmers have really seen these nodules; but if a clover or alfalfa plant is with great care lifted out of the soil so that the root hairs are not torn off, they usually can be discovered; and they are worth looking at, for they are a great boon to agriculture.

Now these bacteria are not always present in our New England soils, in view of the fact that alfalfa is not indigenous, particularly in the East. They often must be supplied; and the best means of doing this is by inoculation at the time of seeding. It cannot be urged too strongly that inoculation is absolutely essential to the successful production of alfalfa. It is best accomplished by scattering soil from a successful alfalfa field on the piece which is to be sown, or by using artificial cultures.

INOCULATION BY SOIL TRANSFER

Inoculation with soil from a successful alfalfa field will nearly always produce the desired results. Care must be taken to avoid the introduction of weed seeds or plant diseases. Since from 300 to 800 pounds per acre are needed, it is advisable to secure the soil from a nearby field. Surface soil through the root-filled area should be taken, spread out in a dark, or at least not sunlighted, place in not too thin

a layer, and allowed to dry out. Seed and soil may be sown together or separately as is most convenient. A fertilizer drill may be used. In any event the soil should be harrowed in promptly for sunlight kills bacteria.

Soil from around sweet clover (*Melilotus alba*) roots is quite as effective as an inoculant as is alfalfa soil. Sweet clover grows frequently along highways and in waste places in Vermont, especially in the Champlain Valley. It is a shrub three to six feet high. The sweet odor of its small white blossoms is noticeable in late June and early July.

The soil may be mixed with the seed and sown with it, or it may be drilled or broadcasted separately. If broadcasted, the soil should be scattered on a cloudy day or toward evening and immediately harrowed in since sunlight kills bacteria.

If the soil has to be carted for a considerable distance, 200 or 300 pounds per acre may be used, mixed with several times its weight of ordinary soil to facilitate even scattering.

INOCULATION BY PURE CULTURES

The artificial cultures sold commercially or supplied by the United States Department of Agriculture, are contained in hermetically sealed tubes. The contents are mixed with clean water, and certain chemicals included with the outfit are added to the solution to form the food supply of the bacteria while they are multiplying. A faint, milky color is observed when they have increased sufficiently in number. The solution is then applied to the seed, which should be dried in a shaded place and sown as soon as possible. Success is more apt to follow inoculation if the seed is sown immediately after it has been dried. The advantages of the artificial culture lie in the greater ease of transportation and application as well as in the absence of the danger of introducing plant diseases or harmful weeds.

TREATMENT THE FIRST SEASON

If seeded in the mid- or in late summer, alfalfa requires no treatment that autumn, unless a growth of more than 12 inches is made before cold weather, in which event, the plants should be clipped back so that they will go into the winter with eight or ten inches of growth. In this condition they will be best able to withstand the winter and should be in good condition to renew their growth the following spring. The first cutting of hay should be made in the late spring.

If the seed has been sown in the spring, but little more than a clipping can be secured in the late summer. This clipping should be made preferably when the basal shoots start and should be made three or four inches high, as the plants will be slow in recovering if cut too low. It may be necessary to cut at some other time than this, as, for instance, when weeds threaten to choke out the young plants, or when the blossoms appear, or when the leaves begin to turn yellow because of disease. Except in the latter case, the clippings are usually left on the ground as a mulch. If the leaves have become diseased, the clippings should be raked up, removed and destroyed. A top-dressing of nitrate of soda will sometimes invigorate diseased plants. Subsequent cutting during the first summer should be similarly handled, except that the growth is usually too heavy to be left on the field.

TREATMENT THE SECOND SEASON

Ordinarily no treatment is required during the second season, except to cut the hay when the plants are about one-tenth in bloom, or, better, when the new crown or basal shoots are starting. The hay should be removed as soon as possible in order to allow the new growth to commence uniformly. If windrows or cocks remain too long on the ground, the underlying alfalfa will be smothered out and the bare spaces thus formed will become centers from which weeds will spread.

No pasturing should be allowed during the first or second seasons, for the reason the crowns do not become sufficiently well developed thus early in the life of the plant to enable it to withstand trampling. From three-fourths to a full crop may be expected the next season after late summer seeding whereas nearly a full crop is usual the second season after spring seeding, if the weeds of the first summer have not seriously injured the stand; yet in the long run under most Vermont conditions it is probably safer to seed in the summer than in the spring.

TREATMENT DURING SUBSEQUENT SEASONS

As long as an alfalfa field shows a perfect stand, with no tendency to run to weeds, no special treatment is needed. If the weeds begin to prove troublesome, it may be well to disc after cutting. This loosens up and aerates the soil, which is decidedly advantageous to the crop. The taproots are not apt to be injured if the discs are set nearly straight and most of the weeds are destroyed. A spike-toothed harrow may follow the disc to level the ground. Discing, however, is apt to be destructive to the alfalfa in sections where the crop does not

thrive. Cutting promotes thrift, especially in the East. Uncut alfalfa becomes unthrifty, and is subject to leaf fungus and other diseases and becomes more readily overpowered by weeds and grass. Late cutting, however, is to be avoided, lest sufficient growth is left to hold the snow and protect the crowns. A foot of growth is none too little. Late September or October mown fields are quite apt to die out.

It is the custom in some sections where a considerable growth of fall weeds or grasses occur, to burn them off the following spring before the alfalfa starts. The field is burned before a strong wind in order to avoid crown injury.

In sections where the soils require liming, and a top dressing seems desirable, the lime may be applied either in the spring or after the first cutting. Ground limestone only should be used, as it is will not injure the alfalfa plants whereas the more acrid forms of lime would be quite certain to do damage. A top-dressing of well-rotted or weed-free barnyard manure may be made during the early winter to advantage on most Eastern soils.

Alfalfa lasts forever in some sections, but not in the East. Here its maximum efficiency rarely exceeds four years. When the stand begins to grow thin, it is well to plow it up and plant to some other crop for awhile before reseeding.

EFFECT OF ALFALFA ON THE LAND

Alfalfa acts like red clover and other leguminous crops in increasing the yields of succeeding crops. Its roots add nitrogen directly to the soil, and, because of their deep-feeding habit, phosphoric acid, potash, lime and other mineral forms of plant food are translocated from the lower to the upper soil layers and made accessible to shallow-feeding crops. The writer has been accustomed to say that alfalfa feeds from three tables, that of the surface soil, that of the subsoil and that of the air, and that, speaking colloquially, it dragged nitrogen down into the surface soil and pulled phosphoric acid, potash and lime up into the surface soil for its own benefit and that of succeeding crops which feed upon its decayed stubble residues. It should be remembered, however, that if the alfalfa is sold from the farm such practice will tend in the long run to denude it, but that if it is fed upon the farm, such a practice will greatly enrich it. However, one can better afford to sell alfalfa than non-leguminous crops.

ADAPTABILITY OF ALFALFA TO ROTATIONS

The value of a successful alfalfa field is so great that one is tempted to let it stand as long as it will produce paying crops. The difficulty sometimes experienced in getting rid of an old stand, the uncertainty of establishing a new one and the high price of the seed, all militate against its utilization in ordinary farm rotations. However, it is securing a place in the farm rotations in spite of these drawbacks, more particularly because of its tendency in these regions to run out in from three to five years. It is not usual in the East for alfalfa to stand more than a few years before it is overcome by weeds. The expense incident to establishing it is the principal drawback to its utilization in a short rotation, such as is customary with red clover. Where the initial cost of its establishment is not too great, the returns the first summer after late summer seeding possibly but not probably may be sufficient to justify turning it under after securing the three cuttings which may be obtained during the first full growing season.

The late Joseph E. Wing of Ohio recommended the following rotation as being adapted to that section: Alfalfa, four years; corn, one year; beardless barley sown with alfalfa, one year. The cultivated corn crop affords an opportunity to destroy any weeds which may have obtained a foothold.

DRAWBACKS

Alfalfa is not without its drawbacks. The methods ordinarily used in raising red clover do not apply to its growth. Much has to be learned by experience as to its special requirements. The first cutting in late spring comes at a time when heavy rains are apt to interfere with its proper curing. It does not cure readily and a good quality of hay, especially from the first cutting, is hard to get. Alfalfa does not reseed itself. Individual plants may live for years but once a plant dies its place is taken by weeds. The three or four hay cuttings procured during a season are apt to come at times when the normal farm work is otherwise engaged. One prominent Vermont alfalfa grower is said to have threatened to cease to produce this crop because he "did not want to be haying all summer long." When pastured, bloating is likely to occur and valuable animals may be lost. The seed is expensive and the cost of properly fitting the ground is relatively large, thus working a hardship if the stand is not a success, as is too often the case.

Furthermore, a serious danger in this region is winter killing due to ice. Wherever from any cause ice sheets form in an alfalfa field,

the crop is killed. There is no way of preventing this trouble. One can only plow, plant to a hoed crop and reseed the following season. Another form of winter killing is seen on ill-drained clay soils, where repeated freezings and thawings lift the roots and tear the crowns. This is more apt to occur with new seedlings than on established fields. Underdrainage and deep plowing tend to remedy this latter situation.

ENEMIES OF ALFALFA

Weeds, especially witchgrass, foxtails, crabgrass and dodder, are the worst enemy of alfalfa in New England. Their destruction is a serious problem. Discing is usually the most effective remedy, as the alfalfa is generally benefited, while the weeds are greatly injured. Crabgrass and sorrel do not trouble if the soil is well limed, for then alfalfa can usually outstrip its enemies. Witchgrass (quackgrass) often gets the best of alfalfa. There is no easy way in which to combat this pest. A farmer who desires to grow alfalfa should first dispose of the witchgrass. The methods outlined in bulletin 149 (free for the asking) or in Farmers Bulletin 464 of the United States Department of Agriculture, will do it. They are laborious and expensive, but they pay their way. They consist in brief of such vigorous cultivation and exposure of the roots to the air and sunlight as to prevent rooting. The foxtails sometimes prove annoying. They are annual grasses which mowings do not destroy and which will seed, if necessary, at the height of an inch. If a thoroughly cultivated crop precedes the alfalfa, the pest will be largely eradicated; but a thorough piece of work and not an ordinary one must be done.

Prevention is 16 times as good as a cure. Therefore it is well to look to one's seed purchases, and not to buy and pay for weed seeds. The last agricultural seed inspection bulletin (No. 200) is especially helpful in this connection, in that it pictures and describes all the common weed seeds purchased in our agricultural seed. He who really wants to get good seed can usually secure it in normal years.

Dodder is a bad alfalfa weed. Its seeds germinate in the ground and the young plants soon attach themselves to the alfalfa seedlings. As soon as the threadlike stem becomes firmly attached to the alfalfa plant, the stem connecting it with the ground withers away and thenceforth the dodder lives entirely on the alfalfa. It is hard to eradicate when once established, and hence great care should be taken to avoid introducing it with the alfalfa seed at seeding time. If it appears in isolated spots

the affected alfalfa plants should be cut very low and removed. Destroying the dodder by burning with different inflammable materials has sometimes proved successful, but it is apt to cost more than the removal of the affected portions of the plants. If badly affected the stand should be plowed up before the dodder goes to seed and the land kept in cultivated crops for two or more years.

The leaf-spot disease is the most common disease which attacks the leaves and stems. This appears as minute black spots on the mature leaves. Leaf-rust produces small reddish spots on the leaves. Powdery and downy mildews form whitish patches of considerable size on the leaves. Another form of leaf-spot disease, which appears in the form of well-defined circular spots which show numerous small black dots scattered over their surface, is sometimes encountered. When any of these diseases begin to prove destructive, the plants should be cut. This invigorates the crop and most of the spores by which the disease is spread are destroyed. The anthracnose disease is destructive locally in the East. It attacks the stems and forms purple patches which gradually increase in size. No effective remedy has been discovered.

Grasshoppers sometimes hurt alfalfa badly. The method of attack set forth in bulletin 189, page 349, should prove efficacious. County agents will gladly indicate how they may be successfully combatted.

YIELDS

Perhaps no other crop requires so many different treatments, depending upon the locality in which it is grown. Hence, early attempts often result in failures and should be made upon a small scale. Many successful alfalfa growers have learned how to produce profitable crops only after several years of trials.

Tremendous stories are told as to alfalfa yields. Under irrigation conditions yields have in some cases approximated ten tons or more to an acre; an authenticated case is on record of a 160 acre quarter section of Montana soil, all in alfalfa, from which an even 1,000 tons had been secured; and other larger stories are also current. Such results are not to be expected in the East, where, when soil conditions are otherwise satisfactory, moisture is apt to be the limiting factor. A well established alfalfa field in Vermont in its heyday in a good grass year should produce certainly three, perhaps four, tons per acre. The New York State Station reports the average of five years' commercial crops, at points in central New York where alfalfa has long been grown, at a figure in excess of four tons.

CHEMICAL COMPOSITION

The writer has often said that if corn were king and clover queen in Vermont, alfalfa was the ace. It is the high card in the farmer's hand. In total dry matter and in digestible dry matter yields it ranks second only—and not always second—to the corn crop, and in digestible protein yields per acre it outranks every crop. The following excerpt from bulletin 152 shows its chemical composition and digestible nutrient values as compared with a few other staple crops:

	CHEMICAL COMPOSITION						DIGESTIBLE NUTRIENTS						
	Water	Ash	Protein	Crude fiber	Nitrogen free extract	Ether extract	Dry matter	Protein	Crude fiber	Nitrogen free extract	Ether extract	Total digestible carbohydrates	Nutritive ratio
Green	%	%	%	%	%	%	%	%	%	%	%	%	1:
Pasture grass	80.0	2.0	3.5	4.0	9.7	0.8	14.2	2.5	3.0	7.1	0.5	11.1	4.4
Timothy	61.6	2.1	3.1	11.8	20.2	1.2	22.3	1.6	6.1	12.9	0.6	20.7	12.9
Hungarian	71.1	1.7	3.1	9.2	14.2	0.7	19.1	2.0	6.4	9.5	0.4	16.8	8.4
Oats and peas	78.7	1.7	3.5	6.0	9.1	1.0	14.9	2.6	3.6	6.1	0.6	11.1	4.3
Fodder corn	79.3	1.2	1.8	5.0	12.2	0.5							
Red clover	70.8	2.1	4.4	8.1	13.5	1.1	19.3	2.9	4.3	10.5	0.7	16.4	5.7
Alfalfa	71.8	2.7	4.8	7.4	12.3	1.0	17.2	3.6	3.2	8.9	0.4	13.0	3.6
Soy bean	75.1	2.6	4.0	6.7	10.6	1.0	16.2	3.1	3.0	8.0	0.5	12.1	3.9
Hays, etc.													
Mixed grasses	15.3	5.5	7.4	27.2	42.1	2.5	50.8	4.2	16.3	25.7	1.3	44.9	10.6
Timothy	13.2	4.4	5.9	29.0	45.0	2.5	47.8	2.8	14.5	27.9	1.3	45.3	16.2
Rowen	16.6	6.8	11.6	22.5	39.4	3.1	54.2	8.1	14.9	25.6	1.5	43.9	5.4
Hungarian	16.5	5.6	8.2	22.6	43.9	3.2	54.3	4.9	15.4	29.4	2.1	49.5	9.1
Corn fodder	42.2	2.7	4.5	14.3	34.7	1.6	39.3	2.5	8.0	25.0	1.2	35.7	8.9
Mixed grasses and clover	12.9	5.5	10.1	27.6	41.3	2.6	47.9	3.8	14.6	24.8	1.5	42.8	11.3
Red clover	15.3	6.2	12.3	24.8	38.1	3.3	48.3	7.1	13.4	24.4	1.8	41.9	5.9
Alfalfa	8.4	7.4	14.3	25.0	42.7	2.2	56.8	10.3	11.8	30.7	0.9	44.5	4.3
Soy bean	11.3	7.2	15.4	22.3	38.6	5.2	55.0	10.9	13.6	26.6	1.5	43.6	4.0
Corn silage*	10.0	5.6	7.7	22.1	51.5	3.1	59.5	3.8	8.2	36.6	2.4	50.2	15.0

*Reduced to 10 percent moisture basis in order to be comparable with other dry roughages

The green alfalfa outranks the other forage crops in protein, both total and digestible; and as hay is exceeded only by the soy bean. In view of the larger tonnage which can be grown when it is well established, it furnishes more actual digestible protein than does the soy bean.

UTILIZATION OF ALFALFA

ALFALFA HAY

Practically all alfalfa grown in New England is hayed. Under favorable conditions three cuttings may be obtained. From 30 to 40 days of good growing weather suffice usually to produce a growth.

TIME OF CUTTING

The crop is cut just as it is coming into bloom, when its feeding value is highest. The starting of the basal shoots which are to form the growth for the succeeding crop is a good signal. If cut then, the new growth is ready to take immediate possession of the ground and no delay results. If, however, the cutting takes place before these shoots are formed, the new growth is delayed until they can be formed; and if the cutting is delayed until they attain a considerable height, they will be cut off by the mower to the injury of the succeeding crop. It is a somewhat delicate matter, this choice of the right date for cutting. If cut too soon on the one hand, or if cut too late on the other, failure may ensue. Wing says in this connection that "At no time can one cut alfalfa before the shoots come; never delay cutting many days after they appear." In case, however, dry weather retards the basal shoot development until after the plants commence blooming, the crop should be cut at once so as to get the best quality of hay. Alfalfa cut late in the fall is seriously weakened. The first week of September is perhaps as late a date as should be chosen. The crop should be a foot high when the snow comes, in order the better to protect the crown. The nearby sixpence, namely, a ton or so of hay this year, is well lost in the interests of the distant dollar, namely, a small deathroll during the winter and a larger next year's crop.

METHODS OF HARVESTING

The hay should reach the barn with the least possible amount of handling and exposure. This is not always possible in these regions and the cuttings must frequently be delayed for several days on account of bad weather. The ordinary haying machinery is used and the practice commonly obtained in the handling of a heavy clover hay will serve for alfalfa. Alfalfa suffers severely if weatherworn, much soluble and digestible material being thus lost. Hay caps may in some cases prove necessary. A three-legged stool upon which the cock is built is sometimes used which permits rapid drying in the event of rain.

IMPORTANCE OF THE LEAVES FOR HAY

Alfalfa hay shatters badly. Two-fifths of the total weight and three-fifths of all the protein are contained in the leaves. Forty-four pounds of leaves contain as much protein as 100 pounds of stems. They are somewhat richer than bran for feeding purposes. Much of the leaf loss ordinarily occurring during harvesting may be obviated if care is used.

SPONTANEOUS COMBUSTION OF HAY

When a too green alfalfa hay is mowed away, it is apt to heat. It often becomes intensely hot, sometimes enough to cure nicely, sometimes enough to ignite if the air gets freely to it. In such cases care should be taken to admit no air into the heated mass, which will then be unable to burn, being smothered for lack of air. If this heating process is not carried too far, a "brown hay" is formed which is well relished by stock and apparently loses none of its feeding value. There is no danger of spontaneous combustion unless the hay is mowed away much too green and moist.

WING'S SUGGESTIONS AS TO HAY MAKING

The late "Joe Wing," the Ohio alfalfa king, says that "to make alfalfa hay, a man needs wide cut mowers, a supply of rakes, forks and men, then unlimited faith and hopefulness." He states that "from observation and habit (he) at last learned the secret of making (alfalfa) hay with no material damage in a land where rain often falls." In setting forth his method he suggests:

1. That "the best hay in all respects is made partly in the shade, in lower turned windrows, in narrow cocks"; that "this indicates the use of the side delivery rake, * * * an admirable tool for helping cure hay * * started before the leaves are dry enough to crumble * * * lay (ing) it up in loose windrows, hidden in part from the burning sun, yet penetrable by the air."

2. That the "careful use of the tedder is helpful; indiscriminate use may do great injury."

3. That the hay should be cocked in "old fashioned * * * cocks small in diameter and as high as can be safely piled"; when "tough and the leaves (are) as dry as it is safe to (handle)"; and that "hay cocked thus green" will shed water well and will not soak out to any extent.

4. That "one can never lay down cast iron rules for hay making"; that "the cock may not need opening at all, but the chances are it will if it is to go in at once," in which event at about ten o'clock, if the day is fair, the cocks made the preceding day are opened, the hay being lifted "tenderly in three, four or more large flakes, just as the cock was laid up, to avoid loss of leaves. After dinner they (may) need turning over once. Then, after drying, they are cocked again and, ultimately, wagons follow and it is taken as fast as possible to the barn."

5. That "hay lying in the swath will be much injured; in the windrows less hurt; and if it is the cock, probably (not) at all (by

rain)"; that it should be "(kept) away from the air as soon as it is getting dry and dews and rains are coming."

6. That to test how dry it should be before mowing, he "take (s) a wisp, choosing some of the moister part, and twist (s) it hard to see if we can wring any moisture from the stems. If not, we put it in the mow as fast as we can get it there. One can put in hay with some moisture in the stems but moisture of rain or dew is sure to spoil the hay. When one or two tons are put in a small mow the hay can hardly be too well cured, but 50 or more tons will keep well even if the hay is pretty tough when put in."

7. That "alfalfa can be dried too much in the field" so that "it will not handle or pack well"; that "it takes experience to teach how dry hay ought to be, (that) one must learn to know (its) feel. If the hay is harsh and brittle it is too dry; if it is damp and limp it is too moist; if any moisture from rain or dew is on it it will spoil."

8. That when the system above outlined and more specifically set forth in his book entitled "Alfalfa Farming in America" is followed "almost no hay is lost no matter how it rains."

ALFALFA MEAL

The manufacture of alfalfa meal from alfalfa hay is a common procedure in the West. This meal is sold in Vermont markets just as it is ground or mixed with other concentrates, such as molasses, bran and corn chop. Its advantages lie in the fact that it may be fed with less waste than hay. However, a pound of alfalfa hay contains no more nutriment when ground into meal than it did before it was ground. No grower in Vermont will go to this trouble, and, in the judgment of the writer, few should buy alfalfa meal at present prices.

ALFALFA FOR SILAGE

Silage made from alfalfa is not to be advised, although the third cutting, usually ready about the time corn is being ensiled, when labor is busily employed and sunlight is becoming a scarce article, may be mixed to advantage with corn silage. Alfalfa silage is apt to be slimy and considerable spoilage losses seem inevitable.

ALFALFA AS A SOILING CROP

The readiness with which alfalfa renews its growth after each cutting, as well as its inherent value, makes it an ideal soiling plant for all classes of stock. Bloating need not be feared. The field from which daily cuttings are taken should be large enough to be cut over

in four or five weeks. Under such conditions the part of the field first cut will be ready for a second cutting by the time the first crop is entirely utilized.

ALFALFA AS A PASTURE CROP

Alfalfa should not be pastured during its first or second season, and even old fields of alfalfa should be grazed sparingly, if at all. Wing unhesitatingly says that "it may almost be said that alfalfa is unfitted for pasturing." It should never be thus used when frozen or soft and muddy, lest the crown be injured. The fall crop is sometimes pastured when other grazing is short. In this event, care should be taken not to pasture too closely, as the plants should enter the winter with some growth upon the crowns. This will enable them to withstand the winter better and also to store up reserve food material for a vigorous early spring growth. The evil effects of trampling may be partly overcome by discing to loosen up the compacted ground. All kinds of live stock may be pastured upon alfalfa. Horses and sheep hurt the stand more than do cattle, as they graze more closely; and hogs are apt to injure it by rooting unless their noses are ringed. Its utilization for hog pasture is extensive throughout the alfalfa regions of the West and is very profitable. An average acre supports ten large hogs continuously during the growing season, especially if a little grain is fed, say a pound of grain a day to 100 pounds live weight.

The principal drawback to the pasturing of cattle and sheep on alfalfa is their tendency to bloat. If, however, the cattle do not go on to the pasture with empty stomachs, especially when the alfalfa is wet, the danger is but slight. If bloating occurs, an inch bit may be tied in the mouth and a piece of rubber tubing passed through the mouth to the first stomach; or, as a last resort, the animal may be tapped, using a trochar or small-bladed knife. The incision is made about 6 inches in front of and slightly below the left hip bone. A straw or quill may be inserted to facilitate the escape of the gas.

FEEDING VALUE OF ALFALFA

Alfalfa, whether green or hayed, is one of the most highly nutritious and palatable of feeds for all classes of farm animals. Its digestible protein content is considerably greater than of red clover, whether green or dried.

Dairy cattle need protein in order to make milk; and alfalfa serves this purpose excellently well. Careful feeding trials indicate that 1½

pounds of alfalfa will replace a pound of wheat bran. At the time of writing bran costs $35. On this basis it is safe to say that if alfalfa hay can be placed in the cows' mangers at $23 a ton, it should compete with bran. A Vermont dairyman who has plenty of well eared corn silage and of alfalfa hay can laugh at the miller.

Beef cattle make good use of alfalfa. It is not a bulky food and they can eat heartily and make rapid gains. It serves a good purpose, furthermore, with young stock.

Sheep find the hay to be an ideal forage. Ewes winter on it in good shape and there is but little wastage; and lambs do well on it also, if fed a little grain. It should not be forgotten, however, that sheep are prone to bloat on alfalfa pasturage.

Hogs are usually fed alfalfa in the green state, either as a soiling crop or as pasture. It may constitute a winter maintenance ration to advantage, bringing sows to the spring farrowing season in excellent condition. Brood sows profit by its use. It is not of itself a fattening ration, being proteinous rather than carbohydrate in character.

Horses may be fed alfalfa, either green or dry. Instances are on record where horses have performed heavy work throughout the summer on nothing but green alfalfa. Its laxative effect prejudices some people against it; but as a matter of fact alfalfa hay and green alfalfa for years have formed the major portion of the ration for many working animals without injurious effect. Used in moderation it is an excellent feed for young growing stock. It does not seem adapted to the needs of idle or but slightly worked horses. They soften and sweat easily when set to work. If fed at all, it were well to be cautious, as overfeeding by persons not understanding the differences between alfalfa and other hays has been said to have resulted disastrously.

Hens find alfalfa to be an excellent feed; and so do all sorts of fowls. They may range the field during the summer or it can be cut green and fed to them. They should not be given access to a newly seeded patch or in large numbers to a small patch lest they destroy it. Very little additional feed will be necessary. Alfalfa meal fed in a mash may be used as a part of the winter ration with good effect in maintaining the egg production, being quite as valuable for this purpose as red clover.

Bees like it and thrive upon it. The honey is of a good quality and many successive crops can be harvested.

Human beings. It will be news to many that alfalfa makes appetizing human food; that alfalfa meal has become a factor in the

preparation of some western housewives' menus; that gems, muffins, cakes and bread, nutritious and palatable dishes, have been made from meal made from alfalfa leaves and the upper stalks, ground, bolted and bleached; that, in short, Nebuchadnezzar of old who ate grass like an ox was simply an early exponent of the simple life.

A SUMMARY OF SUGGESTIONS FOR GROWING ALFALFA IN NEW ENGLAND

Alfalfa is grown with some difficulty on the soils of the North Atlantic States, with the exception of the limestone areas. No doubt it is because of the fact that limestone soils abound throughout the Champlain valley and that sweet clover grows indigenously there that alfalfa has succeeded on the whole better here than elsewhere in Vermont. Outside of the limestone regions liming is always necessary, and even within these areas the practice is often advised. At least a ton to an acre is usually required, and more may be necessary on the heavier soils. Well-rotted barnyard manure is the most satisfactory fertilizer, but a complete commercial fertilizer may be used in its absence.

When the alfalfa is once started under favorable soil conditions, weeds are likely to prove dangerous. Hence it is well to precede the alfalfa for at least one or two seasons with some clean-culture crop. The best method is to manure heavily in late winter or in early spring, to plow and lime, and, at seeding time, to harrow frequently in order to prevent weed growth and to produce the necessary fine tilth and firm seedbed.

Inoculation with nitrogen-fixing bacteria is essential, unless the soil is known to be naturally supplied. The seed should be sown alone at the rate of 20 to 30 pounds per acre, drilled or broadcasted and covered lightly with a smoothing harrow. Sowing with a nurse crop in the early spring is practiced to some extent, but better results are usually obtained by waiting until early summer and seeding the alfalfa alone.

Good results may be obtained, especially by seeding in late July on land which has been repeatedly harrowed for several weeks. The crop is more likely to winterkill, but this danger may be less than that of the combat with weeds which often must be waged if the crop is sown in the spring.

A half bushel of oats to the acre may be seeded with the alfalfa in late summer. These will make considerable growth before being killed. The dead clumps of stems will catch the snow, and thus afford protection to the alfalfa plants.

Some alfalfa "don'ts" suggested by Mr. Westgate are:

"Don't fail to provide for ample inoculation; soil from an old alfalfa field is best.

Don't sow poor or weedy seed.

Don't sow on a weedy soil.

Don't sow on any but a sweet, well-limed soil.

Don't sow on poorly drained soil.

Don't sow on any but a finely prepared, well-settled seed bed.

Don't pasture the first or second year.

Don't lose the leaves; they constitute the best part of the hay.

Don't seed a large acreage to begin with. Experiment on a small area first.

Don't give up. Many prominent alfalfa growers finally succeeded only after many failures."

SOY BEANS

The soy bean is an annual leguminous plant, a close cousin as it were to the cowpea. It is an erect, somewhat hairy, bushy plant, growing from 2 to 4 feet high. Its leaves look somewhat like bean leaves, its clustered flowers are either white or purple, its light colored seed pods an inch or two long, hairy, containing two small seeds and clustering on the main stems and branches. The seeds are of various colors—yellow, white, green, black or brown and are round, somewhat resembling the Canada pea.

The crop has been widely cultivated in Japan, China and India for hundreds of years, where undoubtedly it was originally native. It is grown there for human food purposes but has been rarely used thus either in Europe or America. As a forage crop, however, it has become of increasing importance during the past two decades in many parts of the United States. Its culture is quite common, especially in Tennessee, North Carolina, Virginia, Maryland, Kentucky, and the southern parts of Illinois and Indiana. The earlier varieties mature in Northern New England. Generally speaking, the soy crop requires much the same temperature and soil requirements as corn. It grows well on poorer soil than corn, if inoculated, but makes its best development on fairly fertile loams or clays. On rich soils it is apt to grow foliage rather than seed while on poorer soils the reverse is true. In these northern latitudes the more open and warmer soils as a rule are to be preferred. It does not require as well-drained a soil

for its best development as does corn, although it will not grow in a soil where water stands for any considerable length of time.

There are many sorts of soy beans, differing in size of plant, in size, shape and color of seed and in rapidity of maturity. Only the early varieties should be considered for use here, such as the Early Yellow, Early Brown, Medium Black and Medium Green, maturing in from 75 to 100 days. In this connection, the results of the Windham County trial, set forth on pages 70 to 72, are of interest.

CULTURE AND PLANTING

The soil must be well prepared, lest weeds choke out the young plants. This should consist of deep plowing and subsequent discing and harrowing, until a firm seedbed is secured.

Good seed is especially important. Unless it is fresh and has been properly stored, it is apt to germinate poorly. It should be tested for viability before planting. A shallow planting, preferably one inch and not more than two inches deep, should be practiced. Poor stands result more frequently from too deep planting than from any other cause. A bushel should plant from two to three acres in rows 36 inches apart, or one acre broadcast. Just after corn planting will serve for soy beans.

The cultivation of the crop is a simple matter. The seedling plants usually appear in a week and tillage may then begin. Any good cultivator may be used, and flat cultivation is to be preferred, just such as is commonly employed with corn.

INOCULATION

Like other legumes, the soy bean utilizes the nitrogen of the air and adds it to the soil by means of root nodules. These nodules are caused by certain bacteria. Unless they are present soy beans grow but poorly in the usual types of soil; indeed, many of the plants turn yellow and die. A field may be inoculated either by the soil-transfer method or by the use of the pure cultures, as is set forth on page 49 in connection with the discussion of the alfalfa, to which reference may be made. The former method involves scattering soil from an old, well-inoculated soy bean field over the new ground at the rate of 200 to 300 pounds per acre. To facilitate even distribution this soil should be thoroughly mixed with several times its weight of ordinary soil. It may be either drilled or broadcasted. In the latter case the work should be done toward evening or on a cloudy day, as bright sunshine

is very harmful to the bacteria. The soil transfer method is laborious and costly but effective.

It should be understood that alfalfa soil or cultures will not work with soy beans and vice versa. It is of interest to note, furthermore, that the use of pure cultures is often unsuccessful with soy beans, perhaps because of the oily nature of the seed. Rather larger quantities of soil are needed than with alfalfa; some authorities say as much as 600 pounds per acre.

When growing soy beans, or any new legume for that matter, one does well to plant for the first time a small experimental plat, inoculating thoroughly by the pure-culture method. If this plat is successful, an abundance of soil will be available for inoculating larger fields without danger of introducing weeds or diseases. It should be remarked, however, that successful soy bean growth does not seem to be so vitally bound up with and dependent upon soil inoculation as is the case with some crops; that apparently the special nodule organisms seem somewhat more widely diffused than are the alfalfa bacteria.

Where fertilizers are used, the general practice is to use acid phosphate at the rate of 200 to 300 pounds per acre and—when available—muriate of potash at the rate of 50 pounds per acre. Nitrogen is not needed to any extent, if at all. The crop can gather it from the air. If used, a modicum of nitrate of soda may be supplied.

The high quality of soy bean forage may be noted by comparing the figures shown on page 56. The seed is very rich in protein and fat, rivalling in these respects cotton- and linseed meals. Soy beans are grown as a seed crop, a grain crop for the silo, for the hay mow and for human consumption. The crop, or its seed, may be fed to every animal on the farm except bees.

As seed and grain. Soy bean oil is becoming an article of commerce. It is used as a substitute for linseed oil in certain manufacturing enterprises. The seed is ground and pressed in much the same manner as is flaxseed and the cake is used in cattle feeding. When the crop is grown for its seed, for home use as feed or for sales purposes as such, the harvest should begin as soon as the earlier pods ripen, otherwise they are apt to split and to shed the beans. This is particularly true of the Medium Green variety largely grown in these latitudes. Corn knives or a bean harvester may be used. The crop should be handled gingerly and in the early morning and late afternoon. The green plants and the shed seed should be spread out lest they heat.

Growing soy beans for the grain and for use as feed may be profitable if the yield amounts to 16 bushels or more per acre. Its feeding value is relatively high, being somewhat superior to cottonseed meal for pork, mutton and milk production. It is rich in protein, whereas nearly every other farm produced grain is poor in that nutrient but rich in carbohydrates. It should not be fed alone but in conjunction with less nitrogenous grain feeds.

Tall varieties that do not branch or bear pods close to the ground are desirable for grain production for the reason that they are more easily harvested. The Medium Green seems the best of the varieties now available for use in our northern latitude. It tends, however, to shatter seeds at ripening time.

There seems to be but little to recommend the practice of growing the crop for grain as compared with ensiling the entire crop with corn. In the one case, part of the food value is sacrificed; in the other it is all utilized. The seed should be ground for cattle or horses but need not be thus prepared for swine and poultry. Indeed, in case of severe field shattering, hogs may be turned in as gleaners to advantage.

As a soiling crop, the soy bean works well, though doubtless it is inferior to some other crops which in this latitude will more quickly produce larger dry matter yields.

As a hay crop, soy beans, when properly cut and carefully cured, are nearly or quite as good as alfalfa hay. However, in view of the fact that soy beans are not as a rule to be recommended as a hay crop north of the Ohio river, stress need not be laid on hay making. The short growing season, which tends to encourage seed production at the expense of plant growth, and the general culture of red clover, with which soy beans can scarcely compete as a hay crop, are controlling reasons why hay making is unusual. When cut for hay, a corn knife may be used, the cut plants being handled in small lots and, in due time, cocked. If a mower is used, the hay should be cured in the same manner as is clover hay. A crop which is to be hayed may be cut at any period from the setting of the seed until its leaves begin to turn, but preferably at the time when the pods are well filled.

As pasturage. The soy bean crop is profitably utilized by pasturing in the South, particularly to hogs, especially when fed corn in addition, when lack of labor, bad weather, or other causes interfere with the harvest. It is rarely if ever thus used in the North.

Soy beans and corn. The crop is more commonly grown with corn than with any other crop. It may be planted in alternate hills with the corn in the same row, in alternate rows of each, in alternate series

of two rows of each, or in the same drilled row with the corn. Such fields, when planted in rows, may be harvested together for silage, or as the grower may elect. The testimony of most Vermont farmers who have tried this combination is in its favor.

As silage. Soy beans are sometimes grown by themselves for silage, but the product usually has a rather strong odor which is somewhat objectionable. A mixed corn-soy bean silage makes an excellent and succulent feed. Where soil and climate permit, it is usually better to grow the soy beans in the cornfield than to grow, harvest and ensile the two crops separately.

As grain. Two parts corn to one part beans is as concentrated a bean diet as is advised. Such a mixture will increase by from one-fourth to one-third the digestible protein content of a corn grain ration.

VERMONT TRIALS WITH ALFALFA AND SOY BEANS

Several of the county agents, at one time and another, have carried on demonstrations with alfalfa and with soy beans. The following excerpts are taken from some of their circular letters:

ALFALFA

ADDISON COUNTY, APRIL 1, 1916

1,000 ACRES IN 1915	?000 ACRES IN 1916
HOW NOT TO GROW ALFALFA.	HOW TO GROW ALFALFA.
1. Use poorly drained soil.	1. Use well drained soil.
2. Use no lime.	2. Use 2 tons ground limestone or 1¼ tons burned lime per acre.
3. Inoculate neither soil nor seed.	3. Inoculate the seed with pure culture; or 200-500 lbs. soil from old, well established alfalfa or sweet clover field, when sun is not shining, harrowing in immediately.
4. Use southern grown or any old seed.	4. Use northern grown seed, preferably Grimm.
5. Sow in April with three bushels of grain seed per acre as a nurse crop.	5. Sow May 15-20 with light nurse crop (1½ bu. barley, oats, or wheat); or July 15-Aug. 1, without nurse crop.
6. Leave the nurse until ripe before cutting.	6. Hay off nurse crop in July.
7. Pasture or cut the first year.	7. Leave a stand of 8-12 inches to go into the winter.
8. Never harrow or cultivate.	8. Harrow or cultivate after removing each alfalfa crop, using preferably an alfalfa cultivator. A disc or spring tooth harrow may be used. (Don't be afraid).
9. Cut when in blossom when you get ready.	9. Cut when small new shoots are starting from the ground.

IS IT WORTH ALL THIS TROUBLE? WATCH THE COWS.

BENNINGTON COUNTY, NOVEMBER, 1916 AND JANUARY, 1917

Most of the alfalfa stands that were put in this (1916) summer look well at the present time. Several have a growth of one foot for protection for the winter. Summer seedlings look better than spring seedlings do now. Nine farmers grew 10 acres; 22 will sow in 1917.

FRANKLIN COUNTY, MARCH, 1916

Franklin County is not naturally adapted to alfalfa. Probably it never will be grown by the majority of our farmers, not because it is impossible to grow it on most farms but because most farmers will not meet its requirements. Most failures have been due to this fact. However, if a reasonable care be used and good judgment is employed alfalfa can be grown very successfully.

ORANGE COUNTY, MARCH, 1917

Thirty-four farmers have tried to grow alfalfa but very few so far have succeeded with it (5 successful, 5 a complete failure, 11 fair, 13 new seedings). Half of the crops were seeded down following corn, the rest followed peas and oats, barley, millet, potatoes, sod and garden. The five successes were achieved following corn, potatoes and garden. Seeding without a nurse crop or with oats were the most common methods, although barley, rye, peas and oats, garden, corn and roots were also used. Sixty-one percent of the crops were spring seeded and 44 percent summer seeded. Several farmers are trying both methods. Sixty-six percent of the farmers used lime. All the successful fields were limed. Fifty-eight percent used inoculation, four of the five successful fields being inoculated. Thirty percent were topdressed, and 32 percent used Grimm seed, most of them being on the new seeding. The average amount of seed used per acre was 19.5 pounds.

RUTLAND COUNTY, FEBRUARY, 1917.

Two-thirds of the towns report from one to 40 acres alfalfa, totalling 148 acres.

WASHINGTON COUNTY, OCTOBER, 1916

The demonstration plots are looking well. There are about 50 acres in the county.

WINDHAM COUNTY, APRIL AND JULY, 1916

April. About 50 acres were located on 20 farms in 1915. Some seeded through three winters and two-thirds of it had been through one winter successfully. One-third was seeded in 1915, mid-summer. At only one location was the crop killed out, and that was by standing water in the spring.

July. First crop cut on Valley Fair grounds June 25. One ton (plus) per acre. On July 31, 24 inches high. No fertilizer since August, 1914, when seeded. Similar results attained elsewhere. In looking over alfalfa fields one cannot but be surprised to see how the second crop will come when the first one has been apparently choked out by the witchgrass. Red clover would hardly do as well under similar circumstances. Small fields are being sown in most every town in the county.

WINDSOR COUNTY, JANUARY, 1917

During the past year eight different farmers have sown demonstration plots of alfalfa. Grimm seed was compared with common, June with July sowing, lime with no lime, and inoculation with no inoculation. All but one or two of the plots were looking very well late in the fall. The effects of the various treatments will doubtless show up next year. The alfalfa plots have aroused a good deal of interest, and more will be sown next year.

SOY BEANS

BENNINGTON COUNTY, NOVEMBER, 1916

The soy bean demonstrations, taken as a whole, were very successful. This crop would seem to merit a permanent place in this county as a forage

plant for dairy cattle. It is estimated that a good stand of beans in the corn will increase the value per acre for silage by about $10, to say nothing of their nitrogen gathering value. They are to be fed out in comparison with corn silage.

FRANKLIN COUNTY, MARCH, 1916

Ten demonstrations were completed with soy beans.

Yields. About ten tons per acre green feed where planted alone; where planted with corn, about the same as corn alone. The soy beans reached an average height of about three feet, were well podded and nearly mature.

Varieties. The Medium Green gave by far the best results, with Ito San second, and Mammoth Yellow, third.

How to plant. With corn most satisfactory. Use three to four quarts of beans and six to eight quarts of corn. Mix and plant with planter, occasionally stirring mixture. May be planted alone in rows two feet apart and three pecks of seed per acre. Do not plant beans with corn if you do not use a corn harvester, unless you leave them for the soil. Do not plant the beans with half bushel or over of corn. The beans will be wasted.

Liming. Beneficial but not necessary in most cases.

Inoculation. Very beneficial.

Usage. Put in silo or feed green or in hay. The cows will eat them in any form.

ORANGE COUNTY, MARCH, 1917

About thirty farmers grew soy beans in 1916. The results were good enough to warrant further trial. Twenty reported growing soys in 1915 and 52 intend to grow them in 1917. The Medium Green variety was used on the demonstration plots, planting four quarts soys and eight quarts corn per acre. The seed was mixed in the planter in these proportions and but little extra work was necessary. They were harvested with the corn in the fall and proved no more troublesome than the pigweeds usually found at harvesting time. The yield was light, about a ton per acre in the valleys and a half ton on the hills. Yields of from two to three tons have been obtained in other counties. Three men report that the feeding value of the soys and corn silage was greater than that of corn alone; nine report no difference; and the rest have not yet fed their mixed silage.

The Mammoth Yellow is usually the variety obtained when buying soys unnamed from seed firms. It will not even blossom in Orange county. Since the beans themselves are comparable in feeding value with cottonseed meal, it is easy to see that a crop which matures is to be preferred to one which does not. The Medium Green beans did not mature last year but in every case were well podded.

A few suggestions may be made concerning the growth of soys in 1917.

1. Wonders should not be expected. Soy beans are valuable, analyzing much the same as alfalfa. They ought to yield two tons per acre with corn and eight tons alone green weight. The feeding value ought to reduce the amount of grain fed at least one-tenth.
2. Last year four quarts soys and eight quarts corn were used for seed per acre, but the results indicated that this was too little. It is advised that five to six quarts soys and ten quarts corn be employed using slightly less corn per acre than usual.
3. If a hand planter is used, plant the two seeds separately. There is no gain in planting separately with machine, but the seed must be mixed frequently or the stand will be uneven.
4. The seed should not be placed over two inches deep.
5. If planted on very rich land with a rank growing corn, the beans will be spindling and lop as well as be late in podding.
6. The seed should be inoculated with a pure culture, obtainable from the Federal Department of Agriculture or from commercial firms. The results with inoculation last year were not satisfactory, but there is possibility of greater success.
7. A corn harvester works well as the stems are stiff like field beans and cut rather hard by hand. However those cutting by hand reported no great trouble.

WASHINGTON COUNTY, SEPTEMBER, 1916

Twelve successful demonstrations of soy beans and corn grown together have been planted, totalling somewhat over 180 acres. The main reasons why this makes a good crop for dairy farms are the actual increases in the protein content of the silage and in the nitrogen content of the soil removed from the roots of the bean plant.

The results of growing soy beans are very noticeable on the succeeding crop, because of the nitrogen which their roots leave. Good corn crops have been grown at the Massachusetts station on soils on which corn previously followed many years of successive planting, the only change in procedure being mixed planting with soy beans. This improvement is doubtless to be ascribed to the supply of nitrogen stored in the soil by the bean roots.

The addition of lime makes the beans grow better and adds to their ability to store nitrogen. This has been shown up noticeably in our demonstrations this year.

WINDHAM COUNTY, DECEMBER, 1916

VARIETY TEST

In the spring of 1916, when soys were being planted quite extensively and several varieties were being advocated, there seemed to be need of determining which were and which were not adapted to growth in Windham County. A. A. Dunklee & Sons of South Vernon, volunteered to make such a test.

The bean plot was in very good condition, it having been planted to corn for several years and each time having had a fair application of manure. Early this spring about twenty loads of manure were applied. No commercial fertilizer and no lime were used on the plot this past season. The beans were all inoculated with liquid culture, and were planted in drills three feet four inches apart, and from two to five inches apart. While very small, a heavy hail storm broke some of the young plants, hurting the stand somewhat. The plot was cultivated several times and kept entirely free from weeds during the whole season. On September 12 samples of each variety were taken for analysis at the Experiment Station. A few days later four-fifths of a square rod of each variety was harvested and carefully weighed. The dry matter and protein yields were secured by calculation. These estimated acre yields were probably somewhat larger than the average, although there were plots in the county where some heavier yields were secured.

SOY BEAN VARIETY TEST

(Arranged in order of yields of dry matter per acre)

Variety	Pounds of green fodder	Dry matter percent	Protein percent	Dry matter pounds	Protein pounds
Jet	28,750	24.72	4.22	7107	1213
Mongol	28,550	23.52	4.23	6714	1207
Medium Green	26,300	24.37	4.29	6409	1128
Ohio 9035	27,600	23.08	3.82	6370	1054
Chestnut	27,350	23.12	3.54	6323	968
Royal	29,150	21.22	3.02	6185	880
Early Brown	25,500	23.84	3.79	6079	966
Mikado	27,800	21.81	3.23	6063	897
Select Sable	29,500	20.45	3.53	6032	1041
Wilson	27,900	20.52	3.67	5725	1071
Mammoth Yellow	27,850	20.16	3.25	5614	905
Ito San	23,550	23.81	4.07	5607	958

DESCRIPTION OF VARIETIES

JET gave the largest acre yields of dry matter and protein. This variety is semi-twining, the total length of plant and runners ranging from 48 to 60 inches. The stalks are small and rather weak, resulting in lopping plants which tangle badly with one another. On this account Jet does not seem adapted to planting with corn. It might be used to plant by itself, but even in this case the plants would be badly tangled. Plants were fairly well podded and beans nearly grown.

MONGOL, an upright plant ranging from 42 to 48 inches high, yielded as much protein per acre as Jet but less dry matter. The leaves were very large and the whole plant heavily podded to the very top, the beans being almost mature. The stalks were fairly stiff and it stood up very well through the heavy storms. This is a good variety to plant with corn or alone and seems equal to the Medium Green in every way.

MEDIUM GREEN has been considered the standard for this section. It made good in this test. It had a very stiff stalk and its exceptional standing qualities through the heavy winds of the past season were very marked. This is a very important consideration when planting in corn. Although not yielding quite as much protein per acre, its protein content was as high as the highest. The plants were very heavily podded and the beans were about matured. This is a very good variety.

OHIO 9035, developed in that State, did well. Its acre yield was good, but its protein content was less satisfactory. It is not quite as tall but more spreading than some varieties, being 40 to 45 inches in height. It stood up well, was well podded, and the beans were two-thirds grown. It was rated as third choice for silage purposes, whether grown with corn or alone.

CHESTNUT proved slightly earlier than any of the varieties thus far mentioned. The yield was fairly good with a fair amount of pods. The beans were mature. This is a good variety, particularly for localities where the season is short. It stands up fairly well, being 45 to 50 inches high.

ROYAL proved to be a twining variety with long runners and lopping habits. It tangles badly and was rather late in maturing. Its pods were just beginning to fill at harvest time. It is not a satisfactory variety for use with corn.

EARLY BROWN was a very early maturing variety. Under ordinary conditions of fertilization it does not grow to be very large. It was podded fairly well and the beans were fully matured. It is a suitable variety for use for the silo where the season is short.

MIKADO gave the next to the lowest yield of protein per acre. It grew about 45 inches high, stood fairly erect and its foliage was rather heavy. However, the plants seemed to lack in vigor, its beans being only half grown. It did not compare favorably with the better varieties.

SELECT SABLE proved to be another of the lopping varieties with some runners. There was a fair set of small pods, which had only just begun to fill out. It gave a good yield of protein, but is not adapted to use with corn.

WILSON proved to be another lopping variety much like the Sable but growing longer runners. It produced a fair amount of pods which were, however, only about half grown. It is not adapted for use with corn.

MAMMOTH YELLOW gave a good yield of fodder but was so immature at harvest time that its dry matter and protein contents were low. It did not stand up well and did not reach the blossoming stage. It is not adapted for use with corn or otherwise in this section.

ITO SAN matured very early along with the Early Brown. Its growth was rather small and it did not stand up through the heavy wind. It was fairly well podded and its beans ripened. It is a good variety for regions where the season is very short and the planting must be done very late.

A similar soy bean variety test was carried on by W. S. Allen, of Jacksonville, where the prevailing soil type is more moist, where the planting must usually be done later in the spring and where frost often comes earlier in the fall. The plot was fertilized with 20 loads of manure and 200 pounds of fertilizer per acre with a small amount of lime. The beans were not inoculated because the culture bottle was broken in transit and there was not time to secure more. The beans were planted in drills about three feet apart on the 20th of June. They received the usual amount of cultivation and were harvested the last of September. On this plot the earlier varieties seemed to do the best. The Chestnut and the Medium Brown yielded about equal amounts, the approximate weight of green fodder being a little over 14,000 pounds to the acre. These two varieties were well podded and nearly ripe. The Mongol yielded a trifle more than this, but did not prove to be as mature. The Ito San produced nearly as much and proved the earliest of all, being nearly ripe. The Wilson, Jet, Mammoth Yellow, Sable and Royal all gave good yields, but lacked maturity. For some unaccountable reason the Medium Green gave the poorest yield of all and was not podded as well as the Chestnut.

In West Wardsboro, Clarence Streeter tried out the Ito San, Early Brown, Sable and Mammoth Yellow varieties. These were not planted until the last of June, yet, notwithstanding, made a fine growth and an excellent crop was harvested. The Ito San seemed to do the best under these conditions.

SUMMARY OF SOY BEAN WORK IN 1916

Less than 15 acres of soy beans and corn were grown in Windham County in 1915. In 1916 approximately 30 bushels of seed were used, enough to plant beans with 240 acres of corn and beans.

Twenty-three demonstration plots were carried through the season. These were grown under varying conditions and were located in nearly every town. On most of the plots beans were grown in part alone and in part mixed with corn. Portions were inoculated and others left uninoculated. The results seem to show that it pays to inoculate in order to get a good set of nodules and to secure the soil improvement that follows their formation, but that inoculation does not seem to make much difference in the yield of fodder. A little over half of the demonstrators prefer to grow the beans by themselves and to mix them at the cutter when they fill the silo. The others prefer to grow them mixed with the corn.

Not a single negative answer has been received to the question: "Shall you raise soy beans next year?" Thirty-four grew the soys in 1916 and 17 who did not grow them this year expect to do so in 1917.

It is interesting to note that some of the varieties at South Vernon yielded over 1200 pounds of protein per acre. It would take approximately five tons of red clover hay per acre to furnish this amount. This statement does not discredit red clover, but emphasizes the value of the soy bean crop in the rotation along with the clover as a means of furnishing home grown protein.

WINDSOR COUNTY, NOVEMBER, 1916

Nearly 200 acres of soy beans were planted (by 35 farmers) either with corn or alone. Practically every farmer who grew the crop in 1916 expects to grow it in 1917. The following points have been demonstrated:

1. Soy beans planted with corn at the rate of four quarts of beans to eight quarts of corn per acre have made a growth varying from three to five feet in height.
2. Beans planted in this way have been gathered by the corn harvester without difficulty.
3. No difference has been noticed in the growth of corn on account of the soy beans.
4. Soy beans grown alone made a much heavier growth than when planted with corn.
5. Beans planted without inoculation made a good growth but did not develop nitrogen-bearing nodules on the roots as did the inoculated beans.
6. Soy beans are less susceptible to frost injury than corn.
7. Seed was developed to full size in the case of beans planted alone.
8. Stock like soy beans.
9. All farmers heard from who have tried the beans this year are well pleased and are planning to grow them next year.

DEC13 191?

JUNE, 1917 BULLETIN 205

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Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

AGRICULTURAL SEED

CONCERNING THE GERMINATION OF SEED

by G. P. BURNS, A. K. PEITERSEN and L. H. FLINT

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BULLETIN 205: AGRICULTURAL SEED

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I. SUMMARY

Samples of 365 lots of agricultural seed were drawn in May from local dealers' stocks and were tested for purity and viability (germination). About one-twelfth of the lots were not guaranteed as required by law. Approximately two percent of the lots which were guaranteed were found to be seriously deficient in purity as compared with the promises made by their purveyors. The location of the deficiencies and the failures to furnish guaranty statements may be readily noted by reference to the tables on pages 18 to 42, arranged either by kinds of seed (e. g. millet, oats, timothy, pages 18 to 32) or by names of wholesalers (e. g., E. W. Bailey & Co., Barber and Bennett, pages 33 to 42).

There is abundant evidence at hand indicating that the seed trade is not as yet thoroughly standardized and that it has not adjusted itself to the conditions brought about by the inauguration of inspection activities; and it is quite clear that in some respects the present law is not thoroughly adequate. However, the conditions are notably better than they were five years ago when the law was placed on our statute books, and the wisdom of the enactment appears to be thoroughly established. Furthermore, farmers seem to be asking for and getting better seed. The inspection seems to be worth while, worth the small amount it costs, namely, five hundred dollars annually.

The importance of the home determination of the viability of seed is stressed and simple mechanisms for determining the germination of seed are described on pages 43 to 48.

II. INTRODUCTION

Acting under the authority conferred upon the Station by No. 184 of the Acts of 1912, its sampling agents visited about 40 Vermont towns and villages and gathered during May, 1917, more than 400 samples of agricultural seed offered for sale in the open markets by local dealers 365 of which were tested, as follows:

Alfalfa 13	Oats 20	Peas, field 11
Barley 16	Redtop 16	Rape 4
Clover, alsike 35	Timothy 49	Rye 7
Clover, red 48	Miscellaneous 37	Soy beans 4
Corn 94	Buckwheat 2	Sweet clover 1
Millet 87	Clover, white 2	Wheat 6

These official samples were drawn in the manner prescribed by the rules of the Association of Official Seed Analysts. Purity tests were made by the weight method, a definite amount of seed being taken, its weight determined, pure seed, weed seed and inert matter or dirt separated, and the weight of each determined. The germination tests were made with Brown and Duval germinators, according to the method employed by the Federal Department of Agriculture.

The results obtained are presented in the following pages in tabular form. In the tables on pages 18 to 32 the data are arranged alphabetically under the names of the various kinds of agricultural seed. The trade or brand names, the names and addresses of retailers and wholesalers, the guaranteed and actual purity percentages, the percentage of viable seed (i. e., germination) and the approximate number of weed seeds in a pound are displayed. The presence of ergoted grain is shown in connection with the redtop and timothy tables. The same data are rearranged alphabetically by wholesalers' names on pages 33 to 42. This arrangement facilitates reference by purchasers of seed. For example, a farmer who contemplates buying timothy seed wholesaled by the Brown Seed Company of Brownsville, Texas, and sold by the Smith Company of Smithville, Vermont, and desires as a guide to his purpose to know how well as a matter of fact the Brown Seed Company had lived up to its promise as to the grade of its timothy sales during the previous year, can turn directly to the data, instead of having to dig it out of the 49 analyses listed in the timothy table on pages 18 to 32. Furthermore, he can see at a glance the situation as to promise and performance of all their offerings during the preceding year as judged by station sampling and analyses. This system of alphabetical arrangement long has obtained in connection with the presentation of the analytical results in the fertilizer bulletins and last

year was put into operation likewise in connection with the feeding stuffs bulletin. Then again he who desires to compare the qualities of various brands of timothy may turn to the timothy table as such in order to compare their merits as judged by analysis.

Many samples of seed have been forwarded by individuals for free analysis and tested during the year and several have been sent in for analysis by dealers for the purpose of establishing guaranties. The fees assessed in accordance with state law for analyzing this latter class of seed have been turned into the State Treasury. Since the Station cannot vouch for the authenticity of these samples, the data secured thereon are not included in the tabular statements.

It seems pertinent to say in this connection that a sample which is not truly representative is worse than useless in that it is misleading. It is not at all uncommon for parties to send literally a pinch of seed in a loosely sealed envelope from which more or less escapes in transit, the residual material perhaps representing truly the unimpaired original sample and perhaps not. It is quite common for parties to send a small seed dealer's sample, the analysis of which for obvious reasons may be of but little value.

III. THE STATE AGRICULTURAL SEED LAW

The General Assembly of 1912 passed an agricultural seed law (No. 184 of the Acts of 1912). It went into effect July 1, 1913, and became effective for the seed trade of 1914. The full text of this law appears in bulletin 183, which will be sent without charge to any address on application.

The following synopsis, setting forth in brief form and direct language the duties of the three parties in interest, namely, the wholesale seed house or purveyor, the local dealer, and the Station, should be helpful to all concerned The farmer, that is to say the ultimate consumer, although not specifically mentioned in the law has moral if not legal duties in this connection, as indicated on the next page.

SYNOPSIS OF THE AGRICULTURAL SEED LAW

THE WHOLESALER'S DUTIES

This enactment requires:

1. *That agricultural seed*—the common grasses, clovers and cereals—*shall be truly named and guaranteed as to its purity* and freedom from foreign matter (weed seed, chaff, dirt, etc.) and seed other

than the kind sold, provided such are distinguishable by their appearance.

2. *That agricultural seed shall be deemed to be "adulterated" if it contains more than one ergotized seed to the ounce* or more than one seed of corn cockle and a few other weeds specified by name, unless their presence and amount are declared on the package.

3. *That agricultural seed shall be deemed to be "adulterated" if its purity is substantially less than the statements made in its behalf would indicate.*

4. *That agricultural seed shall be deemed to be "misbranded" if it* is labeled in a false or misleading manner or *is not guaranteed.*

THE LOCAL SEED DEALER'S DUTIES

This enactment requires:

1. *That seed dealers see to it that "every lot or parcel of agricultural seed of five pounds or over sold,* offered or exposed for sale" *shall be truly named* as to its contents *and guaranteed* in writing or in print *as to its purity* and freedom from foreign matter (weed seeds, chaff, dirt, etc.) or seeds other than the kind sold, provided such are distinguishable by their appearance.

2. *That seed dealers see to it that they sell no seed which is adulterated or misbranded* within the meaning of the law (see 2, 3 and 4, above). Local dealers who feel that they cannot know some of the facts as to adulteration may, if they will, protect themselves by securing written statements from the wholesalers from whom they buy, as provided by section 6 of the act.

THE STATION'S DUTIES

This enactment requires:

1. *That the Station test, at specified fees, seed samples submitted for test of purity,* using the funds thus received for the purpose of the act.

2. *That the Station sample agricultural seed* as sold in the open market, *analyse* the samples thus taken, *compare the results* attained *with the guaranties,* and *publish information in full* as to their "character, value and use."

3. *That the Station notify wholesalers and retailers of violation of the law, hold hearings and notify states' attorneys of the results of such hearings,* with a view to prosecution "if in (the) judgment (of

the state's attorney) the circumstances of the case warrant such action."

THE FARMER'S DUTIES

This enactment requires:

1. That the farmer do nothing whatsoever. He may buy the foulest seed that ever was harvested, if he wants to do so; and the law neither forbids his doing so nor shields him from his folly.

Common sense, however, requires:

1. That the farmer, when buying seed, take advantage of the protection afforded by the law.
2. That he note and be guided by the purity statement on the package.
3. That he note and be guided by the weed seed statement on the package.
4. That he insist on a guaranty in case a dealer attempts to sell him seed without the statement required by law.
5. That he study the annual seed inspection bulletins and compare wholesalers' promises and performances.
6. That he buys the better grades, which usually are likely to be the least costly not only in pure seed purchased but in the exclusion of weed seeds.

CONCERNING HIGH AND LOW GRADE SEED

This latter suggestion seems worth elaborating. The farmer who is buying seed should realize that a 100 percent purity statement on a seed package means "pure" seed, and that a 73 percent purity statement on a seed bag means that 27 percent of what he buys consists of weed seeds, dirt and other foreign material. He should try to grasp the idea that purchased dirt means lost money, which is bad enough; but that buying weeds at the price of good seed means not only lost money but lost money at interest, at many times the legal rate, compounding at a usurious rate for long years to come in the shape of millions of weeds, a yearly loss which is quite equal probably to the taxes on the land they occupy. To pay taxes on land which grows mostly weeds, which were bought and paid for in the guise of timothy or clover or redtop, seems like adding insult to injury. Yet listers are inexorable and seed dealers offer cheap—but really costly—seed, full of weed seeds; for some farmers demand it.

The law protects the buyer who exercises care in purchase. In a general way he can form a shrewd estimate of the amount of weed

seed in a given lot of seed by even a cursory survey of the label which the law requires each seller to affix to his offerings. The following excerpt from the 1917 data of Vermont sales accurately displays the general relation existing between a high purity guaranty and a low weed seed content on the one hand and a relatively low purity guaranty and a high weed seed content on the other hand.

HIGH GRADE AND LOWER GRADES COMPARED

Seed	Guaranteed purity	Approximate weed seeds per pound
Alfalfa	99.9	none
Alfalfa	98.4	2,030
Alsike clover	99.3	214
Alsike clover	70	11,750
Alsike clover	93.78	21,780
Redtop	93	1,830
Redtop	80	131,940
Timothy	99.7	none
Timothy	93	43,500

He who buys a brand guaranteed in the high nineties usually is fairly safe, particularly if the station bulletin dealing with the previous year's trade indicates that the brand in question substantially maintained its guaranty statement. But the farmer who deliberately buys a seed carrying a low purity guaranty—and there are many such—cannot expect to get pure goods, any more than he who buys a suit of clothes at $4.79 can expect to wear all wool garments. However, it should be remembered that the guaranty statement does not always indicate thus by indirection the weed seed or other foreign matter content of a sample, for the reason that sometimes the guaranty is overstated.

The weed problem, like the poor, is always with us. If every farmer knew the seeds of our common grasses and clovers as well as he does those of oats, wheat and corn, there would be less weeds bought and paid for. It is not a difficult task to learn the appearance of these seeds. As for the weed seeds, it is only necessary to know that they are weed seeds. In most cases it matters but little what kind of weed seeds they are. The use of a common reading glass and the employment of a few minutes time may save the would-be buyer much future trouble. (In this connection see the 54 illustrations and the written matter on pages 60 to 80 of bulletin 200—free for the asking—which sets forth the appearance of the common weed seeds found in our agricultural seed).

What percentage of purity may be expected? The following table is proof of the statement that dealers are able to furnish seed of high

percentages of purity. They are glad to do so, they prefer to do so as a rule, for such seed gives better satisfaction than does a low grade brand, and a satisfied customer is one's best advertisement.

SAMPLES OF RELATIVELY HIGH QUALITY—VERMONT INSPECTION, 1917

	Guaranty of purity	Purity found
Alfalfa	99.85	99.99
Barley	99.11	99.43
Alsike clover	99.3	99.5
Red clover	99.5	99.72
Corn	99	99.69
Millet	99.54	100
Oats	99.5	99.98
Redtop	94.4	97.48
Timothy	99.8	99.9

A farmer who is buying seed may get some notion, in fact a pretty clear notion, of what sort is offered him by his dealer by observing the brand name and guaranty and then looking up the quality record of the brand as found on sale during the preceding year.

Unfortunately in the seed trade, as in feed and fertilizer trade, many wholesalers feel that they must meet the demands of those farmers who insist on buying only the lowest grades, on getting the most possible for a dollar regardless of quality. The law does not protect such a buyer against the consequences of his own unwisdom, the results of which may affect others as well as himself; for he who buys weedy seed endangers his more thrifty neighbors, whereas the man who buys a low grade fertilizer or a cheap feed damages only himself. Such being the case, it may be well to consider whether more drastic provisions might not be engrafted to advantage on the Vermont enactment, with a view of excluding the lower grades from our markets. Canadian laws prevent the sales of low grades; and they are shipped over the line for us to buy. We seek to exclude undesirable human immigration, federal officers being stationed at Alburg, St. Albans, Richford, Newport and Beecher Falls for this purpose. Would it not be well to keep out undesirable plant immigrants, and, also, to make it less likely that our already large weed family be increased by further importation from our sister states?

IV. DISCUSSION OF THE RESULTS OF INSPECTION

A study of the tables on pages 18 to 32 and of the tables on pages 33 to 42 shows that most wholesalers furnished seed in 1917 which judged by the samples drawn in this inspection are better than their guaranties, that, in other words, their goods seldom fail to be as good

as they are said to be. Speaking broadly, it appears that the guaranties of these houses can be taken without question at face value. It is a matter of regret that, if one is to judge by the results secured in the Vermont inspections of the past three years, this statement cannot be extended to cover all the offerings of all wholesalers. The final remedy for this state of affairs does not lie in the application of the penal section of the law; as already has been set forth, the seed-buying public should inform itself by a study of the facts. However, the situation as to guaranty maintenance is better this year than heretofore as may be seen by the following comparisons:

Year	Number of samples	Number of lots guaranteed	Guaranties substantially made good	Guaranties more than 2 percent high of analyses	Percentage unguaranteed	Percentage seriously deficient
1914	234	191	187	4	18.3	2.1
1915	343	283	269	14	17.8	4.9
1916	466	366	352	14	21.6	3.8
1917	365	335	330	5	8.2	1.4

It should be remarked that the results of the laboratory tests show wide variations in the quality of the seed offered in Vermont markets during the spring of 1917. Some brands were quite weedy. A glance at the last column in the table on pages 18 to 32, shows much variation in this respect. The law does not require the dealer to state the weed-seed content on his label, but the consumer doubtless would be glad to see the law so extended as to include this information, an extension which probably would be opposed strongly; but not by seed users.

The Federal Department of Agriculture has established certain standards of purity for agricultural seed. These are serviceable but they have no legal status. The Vermont law establishes no grades. The dealer may sell the foulest of seed without being in any way amenable to the law, provided that upon each lot of five or more pounds he sets forth clearly and accurately the nature and extent of its foulness. It is for the buyer to keep his eyes open. The law does not protect him if he is cheated in a horse trade, if he buys a spavined animal thinking it is sound. It does protect him in seed purchase, if he reads the statements on the package, so be it that they tell the truth; and he can find out if he will whether or not they are truthful.

VIOLATIONS OF THE LAW

The chief violations in 1917 were:

(1) Failure to furnish the guaranty required by law.

(2) Failure substantially to maintain guaranties.

(3) The undeclared sale of ergoted grains or of the presence of corn cockle or of Russian thistle.

1. *The omission of a guaranty* seems inexcusable, now that the law has been in force for four years; hence, beginning with 1916, such errors of omission as came to the attention of the Station were dealt with, so far as its office is concerned, in accordance with the provisions of the law.

Citations were issued for hearings to be held on May 31 in accordance with Section 6, calling upon about 50 people to appear. A considerable number paid no attention whatsoever to the notification, which of course was their privilege. Several appeared and acknowledged the correctness of the station's claim that they were selling unguaranteed seed. In the main their plea was that the matter had been "overlooked," although almost to a man they acknowledged having received the station's advance warning notice, which apparently had made no serious impression on their minds.

The state's attorneys were notified in all cases as to the results of the hearings. The phraseology of Section 6 of the law requires prosecution "if in his (the state's attorney's) judgment the circumstances of the case warrant such action." At the date of issuance of this bulletin, 16 months after these notifications were sent to the several state's attorneys, so far as the Station is informed, no action has been taken in any case looking towards prosecution.

There can be no clearer cases than were some of those which were reported to certain state's attorneys. In several instances these officials were not sufficiently courteous to acknowledge the receipt of the station's communications. It would be farcical, a sheer waste of time, to repeat the operation. The appropriation is so small that it barely suffices for the expense of sampling, analyzing and reporting. The expense of last year's enforcement of the citation clause of the law was considerable and, the result being what it was, no further attempt has been made to operate this mandatory clause. However, perhaps the effort was not put forth in vain. For some reason the situation is far better than in the past. Whereas in 1914 and 1916 one-fifth and in 1915 one-sixth of the lots sampled were unguarantied, only one-twelfth were found to be thus faulty in the present inspection; and there seems good reason to suppose that nearly half of these technically deficient lots either were actually guaranteed by the wholesaler to the retailer, who had lost or destroyed the statement, or, being oats or wheat, were not offered as seed oats or seed wheat and hence, in accord-

ance with the ruling of the Attorney General, do not necessarily have to carry a guaranty statement. This reduces the deficients to about one in 20. These appear to be in the main the products of wholesalers who either frankly declare that they will pay no attention whatever to the requirement of the Vermont law or who are habitually careless in seeing to it that their goods are guaranteed.

2. *The divergencies between guaranteed purity and actual purity* found on analysis often were very small, and may be explained by sample variation or analytical variation; that is to say, the margin of error necessarily incident to the operations of sampling and analysis might well be considered to cover the divergency between promise and performance. No note should be taken of these cases; indeed the very terms of the law cover such occurrences and its phraseology was shaped designedly with this point in view when it was made to read—"provided that no penalty or liability shall be applicable to a seller of seeds in relation to the quality thereof, if the same is found to be substantially equivalent to the guaranty." In some cases, however, the discrepancy between guaranty and analysis seems too wide to be thus explained (see page 15).

3. *The undeclared sale of ergoted grains* is in a measure excusable in view of the fact that, while a desirable feature of the law, for no one wants to grow ergoted grains, it is not prohibited by the laws of several states from some of which a considerable share of Vermont seed supplies are derived. Ergot is likely to occur only in timothy and redtop. Lots which have been found to be infested seriously in the past have been withdrawn from sale and its presence has been declared on some lots.

The following tabular statement should prove of service to buyers of seed. It concisely sets forth the situation as regards compliance with the law by the several purveyors of seed, 365 samples of whose goods were taken in the spring of 1917, in so far as it relates to:

1. The presence or absence of the guaranty statement.
2. The failure to furnish substantially the proportion of pure seed which is guaranteed.
3. The presence of ergotized seed or of corn cockle or Russian thistle.

Name and address of wholesaler	Number of samples	Number guaranteed	Guaranties made good	Guaranties not less than 1% too high	Ergot, etc., present
Bailey & Co., E. W., Montpelier, Vt.	22	21	18	3	..
Barber & Bennett, Albany, N. Y.	7	7	6	1	..
Barrett Co., Manchester, N. H.	2	2	2	..	1
Breck & Sons Corporation, Joseph, Boston, Mass.	7	5	5	..	..
Burlington Grocery Co., Burlington, Vt.	2	1	1	..	..
Burditt Bros., Rutland, Vt.	1	1	1	..	..
Champlain Seed Co., Burlington, Vt.	5	5	5	..	..
Conklin & Son, E. W., Binghamton, N. Y.	29	28	26	2	..
Cox Co., Charles M., Boston, Mass.	1	1	1	..	..
Craver-Dickinson Seed Co., Buffalo, N. Y.	2	1	1	..	..
Crosby & Co., E., Brattleboro, Vt.	2	2	2	..	..
Curtis & Son, S. P., Rutland, Vt.	1	1	1	..	1*
Dadant & Sons, Hamilton, Ill.	1	1	1	..	1*
Dickinson Co., Albert, Chicago, Ill.	77	74	72	2	5‡
Emerson, Thomas W., Boston, Mass.	5	2	2	..	..
Federal Milling Co., Lockport, N. Y.	2	0	..	..	..
Folsom, H. G., St. Albans, Vt.	1	1	1	..	..
Half Century Store Co., Randolph, Vt.	1	1	1	..	..
Harris, E. E., Morrisville, Vt.	1	1	1	..	..
Holbrook Grocery Co., Keene, N. H.	36	35	34	1	2†
Ide, E. T. & H. K., St. Johnsbury, Vt.	8	8	7	1	..
International Consolidated Record Association, Elmira, N. Y.	2	1	1	..	..
Johnson & Co., W. B., Essex Junction, Vt.	3	3	3	..	..
Jones & Co., J. W., Burlington, Vt.	1	1	1	..	..
Lapelle Poultry Food Co., Swanton, Vt.	2	2	2	..	..
Lyman, A. B., Excelsior, Minn.	1	1	1	..	..
Marsh, L. L., Enosburg Falls, Vt.	1	1	1	..	..
McLeod Milling Co., A. H., St. Johnsbury, Vt.	4	4	4	..	1
Michigan Seed Co., Richford, Vt.	3	3	2	1	..
Middlebrook & Sons, J. O., Burlington, Vt.	3	3	3	..	..
Morehouse & Co., W. H., Toledo, Ohio	20	19	17	2	1
Page Seed Co., Greene, N. Y.	7	6	6	..	..
Rice Seed Co., J. B., Cambridge, N. Y.	15	3	3	..	..
Ross Bros. Co., Worcester, Mass.	1	1	1	..	..
St. Albans Grain Co., St. Albans, Vt.	1	0	..	..	1†
Scarlett & Co., W. G., Baltimore, Md.	1	1	1	..	..
Sherman, F. A., Albany, N. Y.	5	5	5	..	..
Shorey, Geo., Lyndonville, Vt.	1	1	1	..	..
Skeels, H. C., Swanton, Vt.	1	1	1	..	..
Slayton & Co., H. A., Morrisville, Vt.	1	0	..	..	..
Small & Co., W. H., Evansville, Ind.	1	0	..	..	..
Stanford Seed Co., Buffalo, N. Y.	34	34	34	..	2
Stone, W. M., Atwater, Ohio	2	2	2	..	..
Sweat-Comings Co., Richford, Vt.	1	1	1	..	..
Whitney-Eckstein Seed Co., Buffalo, N. Y.	39	38	37	1	1
Winslow, A. H., Bennington, Vt.	1	1	1	..	..

*Russian thistle. †Corn cockle. ‡3 ergot, 2 Russian thistle.

An examination of the results given in this table shows:

1. That approximately eleven-twelfths of the lots were guaranteed and one-twelfth was unguaranteed.

2. That 99 percent of the guaranteed samples were substantially as pure as they were said to be and 96 percent within one percent as pure as they were said to be.

3. That 16 lots contained ergot, corn cockle or Russian thistle.

In the following cases the divergence between promise and fulfillment seems so excessive that special attention should be called to the situation.

A. Dickinson Co., Chicago, Ill.		
Queen Alsike Clover	**Guaranteed 98.84**	**Found 91**
Whitney-Eckstein Co., Buffalo, N. Y.		
Eureka Corn	**Guaranteed 99.7**	**Found 97.75**
E. T. & H. K. Ide, St. Johnsbury, Vt.		
Rye	**Guaranteed 99%**	**Found 93.3%**

It should not be forgotten that the maintenance of guaranty does not tell the whole story. The state law sets no standard. A seller may place any figure he sees fit upon his product, 99 percent or 2 percent as he pleases. This table tells nothing as to the quality of the goods; it simply sets forth the validity of the seller's promises. And some of these guarantees are set at so low a figure as to seem absurd.

It should be said that the Station cannot be as certain of the accuracy of guaranty statements as printed in this bulletin as it is in the case of commercial fertilizers. The statements of sampling agents cannot be checked up as readily—indeed, often they cannot be checked at all. Fertilizer guaranties are definite and unvarying, one lot as compared with another. A 1917 guaranty of Rogers & Hubbard's Oats and Topdressing, for example, is one and the same thing on each and every one of the thousands of bags sold in Vermont. But the guaranties of the agricultural seed brands vary not only in one year as compared with another, but in one lot as compared with another during the same year. And very properly; for while a fertilizer brand is a fairly standardized product a seed brand cannot be so much so. Thus we find in the 1916 inspection the following guaranties on the precise same brands of the same sort of seed (timothy) sold by the same wholesalers: 99 and 99.8; 99 and 99.5; 99.33 and 99.75; 98.7 and 99.7 and a similar situation exists this year. This does not mean carelessness on the part of the wholesaler; on the contrary, it means care, care that to each lot of a necessarily variable product its proper due is accorded. But it is proof positive of the need of state regulation. Furthermore, this situation clearly indicates how little a brand name means, and how much more important is a guaranty statement.

During normal years, when war's alarms do not send the price of acid phosphate toward the skies and when potassium is not a rare element, the composition of a well made standard fertilizer, such a one as that just cited, is almost as constant and unvarying one year as compared with another as is the North Star. On the contrary, a red

clover seed sold, let us say, under the "Red King" brand, may be clean in 1916 and weedy in 1917; a lot sold in Rutland this spring may have been of high grade, whereas another lot sold in the adjoining town of Proctor is foul as perdition; yet if correctly guarantied in each case, the sales are legal. The seed trade is not standardized; perhaps it cannot be. Consequently buyers should watch guaranties full more than brand names.

Concerning the Viability of Agricultural Seed

The state law does not require a guaranty of viability (germination). Such a requirement is made in New Hampshire and perhaps one or two other states, but not in Vermont. The omission was intentional. Purity is a fixed, an unchanging characteristic; but viability varies from month to month, and sometimes rapidly lessens. Since a seed may not be sold promptly, its viability guaranty, correctly stated when the seed was fresh, may be much too high at the time when an official sample is drawn or the consumer makes his purchase. However, the Station tests the official samples as to their viabilities and publishes the results, as shown in the tables on pages 18 to 43.

Some interesting comparisons may be made. Thus, for example, the following maxima, minima and approximate averages are worth noting.

Kind of seed	Samples	Maxima	Minima	Average
Alfalfa	13	93	69	85
Barley	16	100	78	94
Clover, Alsike	35	92	51	84
Clover, Red	48	99	55	88
Corn	93	100	18	94
Millet	37	99	16	84
Oats	20	100	75	95
Redtop	16	63	18	33
Timothy	49	99	74	93
Peas, field	11	100	80	95
Rape	4	98	91	96
Rye	7	98	86	95
Wheat	6	95	32	77

Two of 13 alfalfas; 1 of 16 barleys; 5 of 35 alsikes; 6 of 48 red clovers; 4 of 93 corns; 11 of 37 millets; 1 of 20 oats; 16 of 16 redtops; 2 of 49 timothies; and 2 of 6 wheats; about one lot in five exclusive of corn, were not as viable seed as could be wished, the tests indicating a proportion of non-viable seed greater than one in five.

V. ANALYSES OF AGRICULTURAL SEED (BY KINDS)

NOTE:—The abbreviations of the wholesalers' names appearing in the following tables, pages 18 to 32, are explained as follows:

Bailey—E. W. Bailey & Co., Montpelier, Vt.
Barb. & Ben.—Barber & Bennett, Albany, N. Y.
Barrett—Barrett Co., Manchester, N. H.
Breck—Joseph Breck & Sons Corporation, Boston, Mass.
Burditt—Burditt Bros., Rutland, Vt.
Burl. Groc.—Burl. Grocery Co., Burlington, Vt.
Champlain—Champlain Seed Co., Burlington, Vt.
Conklin—E. W. Conklin & Son Inc., Binghamton, N. Y.
Cox—Chas. M. Cox Co., Chamber of Commerce, Boston, Mass.
Crav.-Dick.—Craver-Dickinson Seed Co., Buffalo, N. Y.
Crosby—E. Crosby & Co., Brattleboro, Vt.
Curtis—S. P. Curtis & Son, Rutland, Vt.
Dadant—Dadant & Sons, Hamilton, Ill.
Dickinson—Albert Dickinson Co., Chicago, Ill.
Emerson—Thos. W. Emerson, Boston, Mass.
Federal—Federal Milling Co., Lockport, N. Y.
Half Cent.—Half Century Store Co., Randolph, Vt.
Harris—E. E. Harris, Morrisville, Vt.
Holbrook—Holbrook Grocery Co., Keene, N. H.
I. C. R. Assoc.—International Consolidated Record Association, Elmira, N. Y.
Ide—E. T. & H. K. Ide, St. Johnsbury, Vt.
Johnson—W. B. Johnson & Co., Essex Junction, Vt.
Jones—A. G. & C. W. Jones, Whiting, Vt.
Lapelle—Lapelle Poultry Food Co., Swanton, Vt.
Lyman—A. B. Lyman, Excelsior, Minn.
Marsh—L. L. Marsh, Enosburg Falls.
McLeod—A. H. McLeod Milling Co., St. Johnsbury, Vt.
Michigan—Michigan Seed Co., Richford, Vt.
Middlebrook—J. O. Middlebrook & Sons, Burlington, Vt.
Morehouse—W. H. Morehouse & Co., Toledo, O.
Page—Page Seed Co., Greene, N. Y.
Rice—J. B. Rice Seed Co., Cambridge, N. Y.
Ross—Ross Bros. Co., Worcester, Mass.
Scarlett—W. C. Scarlett & Co., Baltimore, Md.
Sherman—F. A. Sherman Co., Albany, N. Y.
Shorey—Geo. Shorey, Lyndonville, Vt.
Skeels—H. C. Skeels, Swanton, Vt.
Slayton—H. A. Slayton & Co., Morrisville, Vt.
Slayton—H. A. Slayton & Co., Morrisville, Vt.
Small—W. H. Small & Co., Evansville, Ind.
St. Albans—St. Albans Grain Co., St. Albans, Vt.
Stanford—Stanford Seed Co., Buffalo, N. Y.
Stone—W. M. Stone, Atwater, Ohio.
Sweat-Com.—Sweat-Comings Co., Richford, Vt.
Whit.-Eck.—Whitney-Eckstein Seed Co., Buffalo, N. Y.
Winslow—A. H. Winslow, Bennington, Vt.

ALFALFA

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
———	E. W. Bailey & Co., Montpelier	Bailey	98.4	99.9	88	2030
———	E. G. & A. W. Norton, Vergennes	Burditt	99.75	99.87	85	....
IXL	M. A. Nelson, Montpelier	Conklin	99.85	99.99	82	....
Globe	J. O. Middlebrook & Sons, Burlington	Dickinson	99.85	99.98	93	....
Grimm	F. H. Gillingham, Woodstock	Dickinson	99.9	99.95	91	....
Pine Tree	F. H. Gillingham, Woodstock	Dickinson	98	99.98	83	....
Monadnock	G. J. Stannard, Fair Haven	Holbrook	90	99.56	78	1255
White Mountain	Burlington Grocery Co., Burlington	Holbrook	98.75	99.93	93	....
Grimm	L. L. Marsh, Enosburg Falls	Lyman	95	99.94	92	....
Anchor	M. P. Perley & Co., Enosburg Falls	Morehouse	99	99.93	69	595
Eureka	S. Sherman & Son, Inc., Poultney	Whit.-Eck.	99.5	99.88	80	860
———	Lowell & Brown, Brattleboro	Whit.-Eck.	99.75	99.96	86	150
———	H. P. Munson Estate, Morrisville	Stanford	99.5	99.98	89	....

BARLEY

Six-Row	W. B. Ladd, Enosburg Falls	Bailey	98.5	98.95	78	75
Six-Row	E. W. Bailey & Co., Montpelier	Bailey	98.5	97.9	83	240
———	Lapelle Poultry Food Co., Swanton	Bailey	98	96.71	98	15
Oderbrucker	D. H. McHugh, Middlebury	Conklin	96.9	96.89	98	60
Oderbrucker	E. T. Seabury Estate, Waterbury	Conklin	99.11	99.43	97	....
Ace	C. E. Marshall, West Burke	Dickinson	98	98.47	99	15
Six-Row	E. T. & H. K. Ide, St. Johnsbury	Dickinson	99	98.09	88	....
Six-Row	R. L. Clark, Barre	Dickinson	98.5	99.04	81	45
Six-Row	D. H. McHugh, Middlebury	Dickinson	98	98.77	98	30
Six-Row	M. P. Perley & Co., Enosburg Falls	Dickinson	97	97.67	88	....
Six-Row	H. A. Slayton & Co., Morrisville	Dickinson	96.46	97.69	100	....

BARLEY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
A-260	Trumbull & Pease, White River Junction	Dickinson	99	98.99	100	....
Monadnock	Burlington Grocery Co., Burlington	Holbrook	97	98.28	97	....
Two-Row	E. T. & H. K. Ide, St. Johnsbury	Ide	99	98.3	96	60
Six-Row	Miles McMahon & Son, Stowe	Stanford	90	98.66	98	30
Six-Row	Kempton Mills, Barre	Whit.-Eck.	98	98.95	99	15

ALSIKE CLOVER

Choice	R. L. Clark, Barre	Bailey	90	98.25	85	440
———	S. P. Curtis & Son, Rutland	Barb.-Ben.	97.5	99.63	86	350
Ace	W. C. Fletcher, Brandon	Breck	97	97.65	86	5815
E. M.	W. B. Johnson & Son, Essex Junction	Conklin	95	99.7	90	900
Imperial	E. T. Seabury Estate, Waterbury	Conklin	99.1	99.6	92	1565
Imperial	W. B. Johnson & Son, Essex Junction	Conklin	98.1	99.45	92	445
Imperial	E. G. & A. W. Norton, Vergennes	Conklin	97.5	99.96	91	875
Ace	W. C. Landon & Co., Rutland	Dickinson	95.15	99.48	93	660
Ace	E. T. & H. K. Ide, St. Johnsbury	Dickinson	99	99.48	81	7560
Ace	Robbins & Cowles, Brattleboro	Dickinson	93.7	99.1	88	1350
Ace	City Feed Co., St. Albans	Dickinson	92.14	98.05	82	1115
Globe	F. H. Gillingham, Woodstock	Dickinson	99.3	99.5	86	214
Globe	J. O. Middlebrook & Sons, Burlington	Dickinson	99	99.15	90	1335
Globe	W. B. Ladd, Enosburg Falls	Dickinson	98	99.45	87	445
Kaiser	W. V. Phelps Co. Enosburg Falls	Dickinson	91	94.45	83	10080
Queen	H. A. Slayton & Co., Morrisville	Dickinson	98.84	91	74	40310
Queen	H. A. Slayton & Co., Morrisville	Dickinson	95.02	99.6	81	1102
Pine Tree	F. H. Gillingham, Woodstock	Dickinson	96.3	99.66	87	2145
86651	Valley Grain Co., Brattleboro	Dickinson	95.6	99.3	93	4275

ALSIKE CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
86685	Trumbull & Pease, White River Junction	Dickinson	91.34	97.3	83	3930
White Mountain	Burlington Grocery Co., Burlington	Holbrook	98.5	99.4	93	640
White Mountain	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Holbrook	84	95.4	75	2260
X	Berry & Jones, Montpelier	Holbrook	70	84	51	11750
XX	A. H. McLeod Milling Co., St. Johnsbury	Holbrook	80	91.5	66	12090
XX	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Holbrook	84	93.95	83	6905
Anchor	J. W. Jones & Co., Burlington	Morehouse	99	98.95	80	670
Blue Jay	J. W. Jones & Co., Burlington	Morehouse	98.5	99.35	90	445
Bell	M. P. Perley & Co., Enosburg Falls	Morehouse	98	98.8	82	1100
X-Ray	Cross, Abbott Co., White River Junction	Morehouse	93	97	73	900
Fancy	J. E. Wagner, Milton	Stanford	90	96.75	86	330
———	Miles McMahon & Son, Stowe	Stanford	93.78	99.76	88	21780
Eureka	J. C. Eaton & Son, Lyndonville	Whit.-Eck.	98.5	98.75	86	670
Eureka	E. M. Bixby & Son, Poultney	Whit.-Eck.	98.25	99.25	92	1560
Eureka	Lapelle Poultry Food Co., Swanton	Whit.-Eck.	98	98.9	90	450
Pan-American	Burlington Flouring Co., Burlington	Whit.-Eck.	97	97.3	86	6970

RED CLOVER

Choice	E. W. Bailey & Co., Montpelier	Bailey	97	99	88	635
Globe	E. W. Bailey & Co., Montpelier	Bailey	99.2	99.78	86	705
———	S. P. Curtis & Son, Rutland	Barb. & Ben.	99	99.83	96	180
———	E. M. Bixby & Son, Poultney	Barb. & Ben.	99	98.05	95	....
———	S. P. Curtis & Son, Rutland	Barb. & Ben.	98	98.3	95	1590
Ace	A. H. Merrill Estate, Norwich	Barrett	98	98	76	6426
Crown	E. G. & A. W. Norton, Vergennes	Conklin	99.35	99.72	98	340

RED CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Crown	E. M. Bixby & Son, Poultney	Conklin	99.35	99.53	88	1690
Paragon	W. B. Johnson & Son, Essex Junction	Conklin	98.25	99.2	88	4040
IXL	A. H. Winslow, Bennington	Conklin	....	99.9	95	445
Medium	S. P. Curtis & Son, Rutland	Curtis	98.75	99.65	88	*1165
Ace	D. H. McHugh, Middlebury	Dickinson	99	99.85	92	†730
Ace	W. C. Landon & Co., Rutland	Dickinson	98.31	99.63	88	890
Ace	Burditt Bros., Rutland	Dickinson	98	98.7	91	‡5975
Ace	O. G. Phelps, Milton	Dickinson	....	97.3	90	4245
Globe	Robbins & Cowles, Brattleboro	Dickinson	99.5	99.72	94	700
Globe	F. H. Gillingham, Woodstock	Dickinson	99.15	99.27	94	560
Globe	J. O. Middlebrook & Sons, Burlington	Dickinson	99	99.83	88	420
Mammoth	W. C. Landon & Co., Rutland	Dickinson	99	97.37	91	10040
Medium	W. C. Landon & Co., Rutland	Dickinson	95	97.96	55	7380
Pine Tree	F. H. Gillingham, Woodstock	Dickinson	98.7	99.1	86	2420
Pine Tree	F. H. Gillingham, Woodstock	Dickinson	98.6	99.82	93	175
Pine Tree	R. L. Clark, Barre	Dickinson	98.5	99.84	93	....
Pine Tree	Hatch Hardware Co., St. Albans	Dickinson	97.86	98.87	89	2495
———	E. W. Bailey & Co., Montpelier	Dickinson	98.5	99.27	86	2105
———	Cunningham & Doubleday, St. Albans	Dickinson	97	98.4	79	3675
———	H. A. Slayton & Co., Morrisville	Dickinson	95.02	99.64	79	3240
———	J. O. Middlebrook & Sons, Burlington	Dickinson	....	99.7	83	805
White Mountain	Burlington Grocery Co., Burlington	Holbrook	99.5	99.73	95	260
White Mountain	A. H. Merrill Estate, Norwich	Holbrook	99.5	99.82	96	435
White Mountain	Burlington Grocery Co., Burlington	Holbrook	97	98.25	88	1370
X	Berry & Jones, Montpelier	Holbrook	80	91.72	77	15500

*Russian thistle, 90 per pound. †Russian thistle, 450 per pound. ‡Russian thistle, 270 per pound.

RED CLOVER (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
XX	Burlington Grocery Co., Burlington	Holbrook	95	95.98	89	3115
XXX	Stearns Bros., Springfield	Holbrook	97	98.58	80	3905
———	C. M. McFarland & Son, Barton	Holbrook	95	99.5	89	4725
———	E. T. & H. K. Ide, St. Johnsbury	Ide	98.85	99.66	84	1030
Eureka	Tracy & Maeck, Shelburne	Jones	98	99.67	99	805
Bell	Cross, Abbott Co., White River Junction	Morehouse	98	97.95	89	1610
X-Ray	Cross, Abbott Co., White River Junction	Morehouse	92	99.04	92	2690
———	Miles McMahon & Son, Stowe	Stanford	97.77	99.8	69	350
Reliable	H. P. Munson Estate, Morrisville	Stanford	97.75	99.59	83	980
Eureka	J. H. Hewitt, South Royalton	Whit.-Eck.	99.5	99.98	92	....
Eureka	H. C. Skeels, Swanton	Whit.-Eck.	99.5	99.52	91	1525
Eureka	Lapelle Poultry Food Co., Swanton	Whit.-Eck.	99.4	99.9	93	355
Eureka	Kempton Mills, Barre	Whit.-Eck.	99.25	99.72	90	1535
Pan-American	Burlington Flouring Co., Burlington	Whit.-Eck.	98	98.7	90	4850
Pan-American	Lapelle Poultry Food Co., Swanton	Whit.-Eck.	97	97.4	96	6150

CORN

Early Eight-Row	E. W. Bailey & Co., Montpelier	Bailey	98	96.78	97	....
Early Mastodon	E. W. Bailey & Co., Montpelier	Bailey	98	99.6	88	....
King of the Earliest	E. W. Bailey & Co., Montpelier	Bailey	97	99.74	99	....
King Philip Red	E. W. Bailey & Co., Montpelier	Bailey	98	98.9	96	....
Leaming	E. W. Bailey & Co., Montpelier	Bailey	99	97.44	96	....
Pride of the North	O. G. Phelps, Milton	Bailey	99	99.69	99	....
Red Cob	E. W. Bailey & Co., Montpelier	Bailey	98	98.68	93	....
Sanford White	Lapelle Poultry Food Co., Swanton	Bailey	99	99.42	96	....
Breck	Valley Grain Co., Brattleboro	Breck	99	98.97	90	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Sweepstakes Pedigreed Sweet	G. J. Stannard, Fair Haven	I. C. R. Assoc.	....	97.09	98	....
Burlington Dent	S. P. Curtis & Son, Rutland	Champlain	95	99.14	95	....
Early Eight-Row Canada	R. L. Clark, Barre	Champlain	90	99.75	98	....
Local Sanford	Berry & Jones, Montpelier	Champlain	95	99.36	94	....
Pride of Michigan	R. L. Clark, Barre	Champlain	90	99.6	98	....
R. I. Sanford	R. L. Clark, Barre	Champlain	90	98.58	96	....
Eureka Ensilage	H. E. Shaw, Stowe	Conklin	98.9	99.22	97	....
Leaming	S. P. Curtis & Son, Rutland	Conklin	98.86	100	94	....
Pride of the North	B. T. Henry, North Bennington	Conklin	98.9	99.02	98	....
Sanford White	E. T. Seabury Estate, Waterbury	Conklin	99.26	97.93	98	....
Early Yellow Dent	E. Crosby & Co., Brattleboro	Dickinson	99	98.7	96	....
Eureka	E. Crosby & Co., Brattleboro	Dickinson	99	99.92	97	....
Improved Leaming	E. Crosby & Co., Brattleboro	Dickinson	99	98.12	96	....
Leaming Fodder	Burlington Grocery Co., Burlington	Dickinson	99	100	97	....
Pride of the North	F. H. Gillingham, Woodstock	Dickinson	99	99.57	97	....
Red Cob	E. Crosby & Co., Brattleboro	Dickinson	99	99.58	98	....
Sanford Flint	P. D. Pike & Son, Stowe	Dickinson	99	98.81	99	....
Sanford White	H. E. Shaw, Stowe	Dickinson	99	98.37	92	....
Southern White	E. Crosby & Co., Brattleboro	Dickinson	99	99.5	97	....
Eureka	Half Century Store Co., Randolph	Emerson	90	98.58	97	....
Eureka	Howard Hardware Co., Bellows Falls	Emerson	....	98.09	95	....
Pride of the North	Geo. Shorey, Lyndonville	Emerson	....	96.67	100	....
Leaming Fodder	J. H. Hewitt, South Royalton	Holbrook	99	98.21	98	....
Leaming	Stearns Bros., Springfield	Holbrook	97.5	99.1	18	....
Sanford White	J. H. Hewitt, South Royalton	Holbrook	92	99.41	99	....
Grand Champion	W. C. Fletcher, Brandon	I. C. R. Assoc.	95	99.01	95	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Early Dent	W. B. Johnson & Son, Essex Junction	Johnson	99.8	99.9	99	....
Red Cob	Lapelle Poultry Food Co., Swanton	Lapelle	97	98.39	96	....
Longfellow	A. H. McLeod Milling Co., St. Johnsbury	McLeod	90	99.28	99	....
Michigan Dent	E. T. & H. K. Ide, St. Johnsbury	Michigan	100	99.01	99	....
Minnesota No. 13	W. B. Ladd, Enosburg Falls	Michigan	99.95	98.91	99	....
Vermont Dent	W. B. Ladd, Enosburg Falls	Michigan	90	97.92	98	....
King of the Earliest	J. O. Middlebrook & Sons, Burlington	Middlebrook	95	99.82	98	....
———	J. O. Middlebrook & Sons, Burlington	Middlebrook	95	99.5	96	....
Eureka	Burlington Grocery Co., Burlington	Morehouse	95	98.07	93	....
Eureka White	M. P. Perley & Co., Enosburg Falls	Morehouse	98	97.27	91	....
Golden Nugget	M. P. Perley & Co., Enosburg Falls	Morehouse	99	97.62	34	....
Sanford White Flint	A. H. McLeod Milling Co., St. Johnsbury	Morehouse	99.5	99.21	96	....
Early Triumph	E. G. & A. W. Norton, Vergennes	Page	90	99.8	98	....
Early Yellow Canada	E. G. & A. W. Norton, Vergennes	Page	96	99.8	98	....
Luce's Favorite	S. Sherman & Son, Inc., Poultney	Page	90	99.19	94	....
Page's High Bred Eureka	E. G. & A. W. Norton, Vergennes	Page	95	97.92	99	....
Page's High Leaming	E. G. & A. W. Norton, Vergennes	Page	90	98.89	94	....
Pride of the North	S. Sherman & Son, Inc., Poultney	Page	90	99.07	95	....
West Branch	S. Sherman & Son, Inc., Poultney	Page	90	99.6	90	....
Early Canada	H. P. Munson Estate, Morrisville	Rice	....	99.5	100	....
Early Yellow Canada	W. C. Fletcher, Brandon	Rice	....	98.13	92	....
Eureka	W. C. Landon & Co., Rutland	Rice	....	95.1	94	....
Leaming	Miles McMahon & Son, Stowe	Rice	90	96.93	92	....
Leaming	W. C. Landon & Co., Rutland	Rice	....	95.81	95	....
Longfellow	Howard Hardware Co., Bellows Falls	Rice	....	99.58	96	....
Mastodon	Hatch Hardware Co., St. Albans	Rice	90	99.5	94	....

CORN (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Ninety-day Dent	Miles McMahon & Son, Stowe	Rice	90	99.31	97	....
One hundred-day Dent	W. C. Landon & Co., Rutland	Rice	....	97.49	99	....
Red Cob	Howard Hardware Co., Bellows Falls	Rice	....	97.73	98	....
Sanford White	S. A. Reed, Windsor	Rice	....	97.68	94	....
Southern White	Howard Hardware Co., Bellows Falls	Rice	....	95.4	96	....
———	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Rice	....	97.82	95	....
Eureka	Valley Grain Co., Brattleboro	Ross	90	98.77	94	....
Eureka	B. F. Henry, North Bennington	Sherman	90	99.1	99	....
Leaming	H. W. Myers & Son, Bennington	Sherman	90	98.9	99	....
Pride of the North	H. W. Myers & Son, Bennington	Sherman	90	98.97	97	....
Stowell's Evergreen	H. W. Myers & Son, Bennington	Sherman	80	99.36	97	....
———	B. F. Henry, North Bennington	Sherman	90	99.11	64	....
Early Triumph	M. A. Nelson, Montpelier	Stanford	90	98.6	98	....
Eureka	S. P. Curtis & Son, Rutland	Stanford	90	99.33	97	....
Golden Harvest	W. H. Adams, Vergennes	Stanford	90	98.38	78	....
Imperial Leaming	S. P. Curtis & Son, Rutland	Stanford	98.86	98.13	95	....
Improved Minnesota King	S. P. Curtis & Son, Rutland	Stanford	90	99.31	99	....
Longfellow	S. P. Curtis & Son, Rutland	Stanford	90	97.75	88	....
Northern Wonder	E. M. Bixby & Son, Poultney	Stanford	90	97.15	93	....
One hundred-day Dent	Berry & Jones, Montpelier	Stanford	90	98.21	97	....
Perry's Hybrid	W. B. Ladd, Enosburg Falls	Stanford	90	98.9	92	....
Pride of Nashua	W. H. Adams, Vergennes	Stanford	90	100	92	....
Sanford White	S. P. Curtis & Son, Rutland	Stanford	90	99.14	97	....
Sweet Corn	M. P. Perley & Co., Enosburg Falls	Stanford	95	98.15	97	....
Leaming Fodder	W. V. Phelps & Co., Enosburg Falls	Sweat-Com.	99	98.96	98	....

CORN (CONTINUED)

Trade name.	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Longfellow	A. H. Winslow, Bennington	Winslow	90	95.56	95	....
Eureka	Kempton Mills, Barre	Whit.-Eck.	99.7	97.75	97	....
Indian	A. H. Winslow, Bennington	Whit.-Eck.	98	99.4	99	....
Leaming	Kempton Mills, Barre	Whit.-Eck.	90	99.14	89	....
Longfellow	A. H. Winslow, Bennington	Whit.-Eck.	98	99.29	96	....
Pedigree Leaming	J. W. Jones & Co., Burlington	Whit.-Eck.	90	100	96	....
Sanford White	E. E. Harris, Morrisville	Whit.-Eck.	98	98.71	93	....
MILLET						
Japanese	H. E. Shaw, Stowe	Bailey	98	99.96	95	805
Japanese	A. H. Winslow, Bennington	Barb. & Ben.	99.54	99.98	87	270
Hungarian	Trumbull & Pease, White River Junction	Breck	....	99.95	74	1045
Japanese	M. P. Perley & Co., Enosburg Falls	Breck	98	99.88	97	1870
Japanese	M. A. Nelson, Montpelier	Breck	98	99.87	95	1710
Japanese	J. C. Eaton & Son, Lyndonville	Breck	....	99.9	90	1605
Choice German	E. G. & A. W. Norton, Vergennes	Conklin	98.9	99.94	98	2355
Choice Hungarian	J. O. Middlebrook & Sons, Burlington	Conklin	97	99.86	44	2010
Japanese	J. O. Middlebrook & Sons, Burlington	Conklin	97	99	89	2470
German	Valley Grain Co., Brattleboro	Dickinson	98.9	99.96	74	810
German	Valley Grain Co., Brattleboro	Dickinson	98.3	99.96	75	990
Hungarian	H. P. Munson Estate, Morrisville	Dickinson	99	99.98	89	180
Hungarian	Valley Grain Co., Brattleboro	Dickinson	98.8	99.95	86	1635
Japanese	Hatch Hardware Co., St. Albans	Dickinson	98.6	99.94	98	1440
Japanese	H. A. Slayton & Co., Morrisville	Dickinson	98.33	99.96	99	1145
Japanese	Burditt Bros., Rutland	Dickinson	98	99.92	99	1620
Japanese	Field & Lawrence, Bellows Falls	Dickinson	97.5	99.91	74	1855
Japanese	W. C. Landon & Co., Rutland	Dickinson	97	99.88	93	2555

MILLET (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Hungarian	Geo. Shorey, Lyndonville	Emerson	....	99.9	38	2660
Japanese	Trumbull & Pease, White River Junction	Emerson	98	99.87	70	3510
Hungarian	C. M. McFarland & Son, Barton	Holbrook	97	99.94	74	1046
Japanese	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Holbrook	90	98.48	95	12366
———	Kempton Mills, Barre	Holbrook	89	94.97	85	11140
Japanese	E. T. & H. K. Ide, St. Johnsbury	Ide	98	99.96	98	702
Hungarian	Cross, Abbott Co., White River Junction	Morehouse	92	99.97	77	3524
Japanese	Cross, Abbott Co., White River Junction	Morehouse	92	99.92	79	2295
Japanese	J. E. Wagner, Milton	Skeels	97	97.62	99	4540
Japanese	A. H. McLeod Milling Co., St. Johnsbury	Small	....	97.01	16	6220
German	S. P. Curtis & Son, Rutland	Stanford	94	99.96	83	90
Hungarian	S. P. Curtis & Son, Rutland	Stanford	97.94	99.97	81	350
Japanese	H. P. Munson Estate, Morrisville	Stanford	96.49	99.74	94	4185
Japanese	Robbins & Cowles, Brattleboro	Stanford	95.67	99.82	93	4935
German	S. Sherman & Son, Inc., Poultney	Whit.-Eck.	97	99.96	92	1310
Hungarian	S. Sherman & Son, Inc., Poultney	Whit.-Eck.	97	99.99	96	345
Japanese	J. H. Hewitt, South Royalton	Whit.-Eck.	97	99.84	92	4230
Japanese	H. M. Brown & Co., Castleton	Whit.-Eck.	96	99.7	94	6950
Japanese	P. D. Pike & Son, Stowe,	Whit.-Eck.	94	95.19	96	10790

OATS

Pennant	E. E. Harris, Morrisville	Bailey	99.5	98.54	99	585
Pennant	O. G. Phelps Co., Milton	Bailey	....	99.9	99	15
White	M. P. Perley & Co., Enosburg Falls	Bailey	98.5	99.9	99	30
Northern Wonder	S. P. Curtis & Son, Rutland	Conklin	98.41	99.65	92	540
Northern Wonder	H. E. Shaw, Stowe	Conklin	97.8	98.4	96	270

OATS (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Northern Wonder	E. T. Seabury Estate, Waterbury	Conklin	97.5	97.33	93	75
———	City Feed Co., St. Albans	Cox	90	98.52	96	120
Crosby's Recleaned	F. J. Nutting, Brandon	Crosby	99.78	99.16	90	105
Illinois Berry	C. E. Marshall, West Burke	Crosby	99.78	99.47	97	75
———	E. T. & H. K. Ide, St. Johnsbury	Ide	98	99.44	89	15
Johnson's Fancy	W. B. Johnson & Son, Essex Junction	Johnson	99.25	99.86	98	....
———	Lapelle Poultry Food Co., Swanton	Lapelle	99.5	99.98	99	15
Marsh's Perfection	L. L. Marsh, Enosburg Falls	Marsh	99.34	99.99	93	....
A	A. H. McLeod Milling Co., St. Johnsbury	McLeod	98.5	99.69	100	60
———	Geo. Shorey, Lyndonville	Shorey	90	99.61	94	60
———	H. A. Slayton & Co., Morrisville	Slayton	....	99.34	97	225
Scottish Chief	Miles McMahon & Son, Stowe	Stanford	90	96.9	75	270
———	H. W. Myers & Son, Bennington	Stanford	90	98.2	91	255
———	St. Albans Grain Co., St. Albans	St. Albans	....	94.14	90	*15

*Corn cockle.

REDTOP

Fancy	A. H. Winslow, Bennington	Barb. & Ben.	91.25	88.53	63	120000
Imperial	Robbins & Cowles, Brattleboro	Conklin	93	92.29	22	1830
No. 1	Lovell & Brown, Brattleboro	Conklin	93	88.66	25‖	17770
No. 1	M. A. Nelson, Montpelier	Conklin	92.6	92.25	41‖	34460
Ace	Robbins & Cowles, Brattleboro	Dickinson	90.1	89.67	30	†12730
Ace (recleaned)	W. C. Landon & Co., Rutland	Dickinson	90	90.2	44	4805
Fancy	G. J. Stannard, Fair Haven	Dickinson	92	92.9	30	*10640
Unhulled XX	Robbins & Cowles, Brattleboro	Dickinson	52.88	51.97	18	20735
Monadnock	Howard Hardware Co., Bellows Falls	Holbrook	92.16	93.19	39	‡29320
White Mountain	Burlington Grocery Co., Burlington	Holbrook	80	83.89	40	¶131940

*1.702 ergot. †878 ergot. ‖Claimed by shippers to be old seed; that they have not shipped this brand for two years.

REDTOP—(CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
———	Burlington Grocery Co., Burlington	Holbrook	95	95.38	51	14190
Eclipse	A. H. McLeod Milling Co., St. Johnsbury	McLeod	94.4	97.48	25	§1135
Fancy	Cross, Abbott Co., White River Junction	Morehouse	92	92.77	37	19715
Eureka	E. T. Seabury Estate, Waterbury	Whit.-Eck.	94	94.96	18	6730
———	H. K. Foster, South Royalton	Whit.-Eck.	94	95.53	27	3530
———	P. D. Pike & Son, Stowe	Whit.-Eck.	90	91.98	24	37870

TIMOTHY

Pine Tree	A. H. Merrill Estate, Norwich	Barrett	99.5	99.3	92	*725
Durham	O. G. Phelps Co., Milton	Bailey	99.5	99.5	98	1090
Acme	E. T. Seabury Estate, Waterbury	Conklin	99.8	99.3	95	1140
Arrow	W. B. Johnson & Son, Essex Junction	Conklin	99.1	98.75	97	....
King	S. P. Curtis & Son, Rutland	Conklin	99.6	99.6	94	1770
Bison	A. H. Winslow, Bennington	Dickinson	97	98	90	3135
Durham	S. A. Reed, Windsor	Dickinson	99.5	99.9	93	225
Globe	H. A. Slayton & Co., Morrisville	Dickinson	99.85	99.75	97	445
Globe	W. C. Landon & Co., Rutland	Dickinson	99.8	99.9	93	575
Globe	E. M. Bixby & Son, Poultney	Dickinson	99.75	99.2	96	1125
Globe	F. H. Gillingham, Woodstock	Dickinson	99.7	99.85	98	225
Pine Tree	Robbins & Cowles, Brattleboro	Dickinson	99.6	99.5	96	†900
Pine Tree	W. C. Landon & Co., Rutland	Dickinson	99.5	99.65	96	450
Pine Tree	E. M. Bixby & Son, Poultney	Dickinson	99	99.65	93	....
Pine Tree	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Dickinson	97	99.2	93	670
White Pine	W. B. Ladd, Enosburg Falls	Dickinson	96	98.7	99	450
60642	J. O. Middlebrook & Sons, Burlington	Dickinson	99.1	99.1	93	7515

*225 ergoted seed per pound. †450 ergoted seed per pound.
‡14.253 ergot. ¶6990 ergot. §1135 ergot.

TIMOTHY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Frontier	Half Century Store Co., Randolph	Whit.-Eck.	97	96	95	¶13960
Gold Medal	P. D. Pike & Son, Stowe	Whit.-Eck.	99.7	99.85	95	....
Monadnock	M. P. Perley & Co., Enosburg Falls	Folsom	99.78	99.6	95	210
Half Century	Half Century Store Co., Randolph	Half Cent.	99.7	99.11	96	....
Green Mountain	E. E. Harris, Morrisville	Harris	99.5	99.94	97	265
Pine Tree	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Holbrook	99.5	99.85	96	....
White Mountain	A. H. Merrill Estate, Norwich	Holbrook	99.7	99.4	81	670
White Mountain XX	Burlington Grocery Co., Burlington	Holbrook	98	98.45	91	2025
White Mountain XXX	Burlington Grocery Co., Burlington	Holbrook	99.6	98.54	99	1550
X	C. M. McFarland & Son, Barton	Holbrook	95	96.5	90	*15075
X	Kempton Mills, Barre	Holbrook	93	93.5	78	43500
XX	C. M. McFarland & Son, Barton	Holbrook	98.92	99.25	91	2240
———	E. T. & H. K. Ide, St. Johnsbury	Ide	99.45	98.9	74	890
———	J. C. Eaton & Son, Lyndonville	Ide	99.5	99.55	98	....
———	W. B. Johnson & Son, Essex Junction	Johnson	99.08	99	87	1345
Fancy	A. H. McLeod Milling Co., St. Johnsbury	McLeod	99.45	99.82	74	670
A	Cross, Abbott Co., White River Junction	Morehouse	92	92	87	†17840
Anchor	Cross, Abbott Co., White River Junction	Morehouse	99	99.65	94	655
Anchor	M. P. Perley & Co., Enosburg Falls	Morehouse	....	99.65	92	1045
Bell	M. P. Perley & Co., Enosburg Falls	Morehouse	98	99	84	1103
Choice	H. M. Brown & Co., Castleton	Stanford	99	99.1	91	3120
Honor	J. E. Wagner, Milton	Stanford	99.7	99.55	93	450
Honor	Miles McMahon & Son, Stowe	Stanford	99.7	99.25	91	660
Liberty	S. P. Curtis & Son, Rutland	Stanford	99.5	99.35	89	‡445
Liberty	H. P. Munson Estate, Morrisville	Stanford	99.5	99.2	94	§4705

*Ergot, 1575 per pound. †Ergot, 1575 per pound. ‡Ergot, 225 per pound. §Ergot, 675 per pound. ¶Ergot, 1125 per pound.

TIMOTHY (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Field Peas, No. 1	E. T. Seabury Estate, Waterbury	Conklin	93	98.97	100	....
Field Peas	Geo. Shorey, Lyndonville	Holbrook	98	98.7	98	....
Gold Medal	J. W. Jones & Co., Burlington	Whit.-Eck.	99.7	99.5	92	670
Gold Medal	H. K. Foster, South Royalton	Whit.-Eck.	99.5	99.58	94	....
Gold Medal	J. H. Hewitt, South Royalton	Whit.-Eck.	98.7	99.2	93	....
Pan-American	H. W. Myers & Son, Bennington	Whit.-Eck.	99.7	99	93	725
Pan-American	Tracy & Maeck, Shelburne	Whit.-Eck.	99.5	99	94	890
Pan-American	Half Century Store Co., Randolph	Whit.-Eck.	94.5	99.14	99	1070
———	Burlington Flouring Co., Burlington	Whit.-Eck.	95.5	98.8	93	1775

*Russian thistle, 270 per pound.

MISCELLANEOUS

Soy Bean Roosevelt	Burlington Flouring Co., Burlington	Scarlett	97	97.89	88	....
Soy Bean	H. P. Munson Estate, Morrisville	Stanford	90	99.99	92	....
Soy Bean Roosevelt	Hatch Hardware Co., St. Albans	Stone	90	99.73	99	....
Soy Bean Medium Green.	Hatch Hardware Co., St. Albans	Stone	90	95.69	75	....
Buckwheat	Berry & Jones, Montpelier	Holbrook	....	97.47	80	990
Buckwheat	Kempton Mills, Barre	Whit.-Eck.	99	99.62	98	180
Clover, Sweet Scorefine	D. H. McHugh, Middlebury	Dadant	88	99.77	89	*720
Clover, White	R. L. Clark, Barre	Bailey	85	96.26	87	2085
Clover, White XXX	LaFountain. Woolson Co., Springfield, White River Junction, Windsor	Holbrook	73.5	98.25	79	4170
Field Peas	R. L. Clark, Barre	Crav.-Dick	99	98.36	93	....
Field Peas	Burlington Grocery Co., Burlington	Crav.-Dick.	....	97.16	95	....
Field Peas	Burditt Bros., Rutland	Dickinson	99	100	93	....
Field Peas, Pine Tree	E. T. & H. K. Ide, St. Johnsbury	Dickinson	....	96.51	92	....
Field Peas, Wh. Eye Marrow	E. G. & A. W. Norton, Vergennes	Conklin	98.16	100	80	....

MISCELLANEOUS (CONTINUED)

Trade name	Name and address of retailer	Wholesaler	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
Field Peas, Cambridge	Field & Lawrence, Bellows Falls ...	Rice	....	97.83	99	....
Field Peas	H. P. Munson Estate, Morrisville	Rice	....	99.29	98	....
Field Peas	Half Century Store Co., Randolph	Whit.-Eck.	93	96.29	97	....
Field Peas (Canada)	J. H. Hewitt, South Royalton..	Whit.-Eck.	....	99.46	95	....
Rape	A. H. Winslow, Bennington	Barb. & Ben.	99	98.43	96	75
Rape	E. T. & H. K. Ide, St. Johnsbury ...	Ide	99	99.94	98	....
Rape ..... Dwarf Essex ..	H. P. Munson Estate, Morrisville	Stanford	90	99.92	98	....
Rape,	W. H. Adams, Vergennes	Stanford	90	99.91	91	....
Rye, Spring	W. B. Johnson & Son, Essex Junction ..	Bailey	96	99.04	98	....
Rye, Spring, White Mt.	Burlington Grocery Co., Burlington	Holbrook	98.5	99.29	94	†75
Rye, Spring	E. T. & H. K. Ide, St. Johnsbury ...	Ide	99	93.33	91	....
Rye, Winter	Kempton Mills, Barre	Breck	98.9	98.22	98	....
Rye, Winter	J. O. Middlebrook & Sons, Burlington	Middlebrook	90	95.86	98	15
Rye, Winter, Anchor	M. P. Perley & Co., Enosburg Falls ..	Morehouse	98	96.98	98	45
Rye, Winter	H. P. Munson Estate, Morrisville	Stanford	90	97.71	86	150
Wheat, Spring ..	R. L. Clark Barre	Burl. Groc.	99	99.36	95	....
Wheat, Spring ..	Berry & Jones, Montpelier	Burl. Groc.	....	99.26	97	15
Wheat, Spring ..	E. W. Bailey & Co., Montpelier	Dickinson	98	98.95	94	74
Wheat, Spring ..	Geo. Shorey, Lyndonville	Federal	....	94.22	55	60
Wheat, Spring ..	LaFountain, Woolson Co., Springfield, White River Junction, Windsor	Holbrook	99	97.21	86	390
Wheat, Winter ..	Geo. Shorey, Lyndonville	Federal	....	92.69	32	165

†30 ergoted grains per pound.

PLATE I—Varying degrees of vitality. Kernels at left, 3 weak, 3 dead; at center, 6 strong; at right, 3 weak.

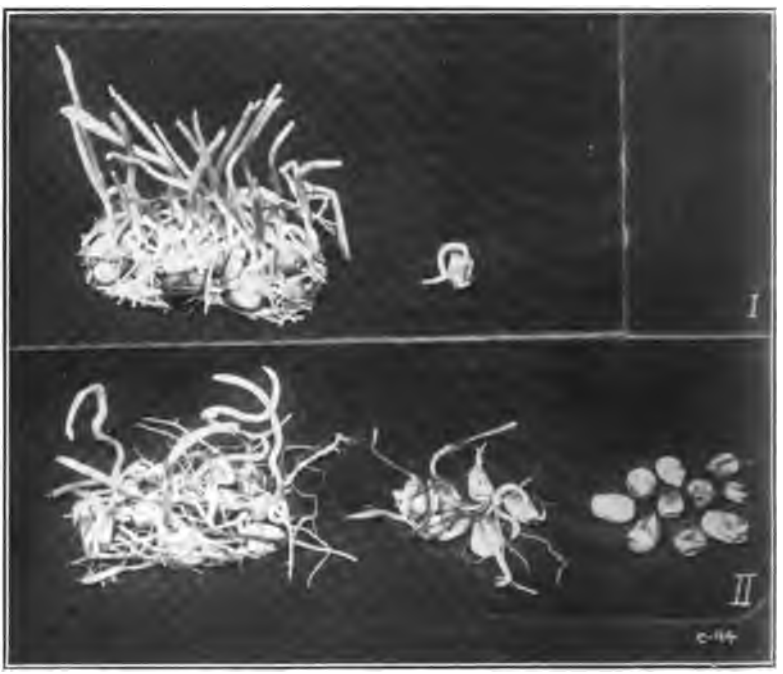

PLATE II—Upper half, 24 strong kernels, one weak. Lower half, 9 strong kernels, 6 weak, 10 dead.
Is it worth while to choose seed corn carefully?

PLATE III—The Sawdust Box. A satisfactory home-made type.

PLATE IV—The Rag Doll. Costs about ten cents. Does satisfactory work.

The Station is indebted to the courtesy of the Iowa Station for the loan of Plates I-IV.

VI. ANALYSES OF AGRICULTURAL SEED (BY WHOLESALERS)

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
E. W. BAILEY & CO., MAIN ST., MONTPELIER, VT.					
Alfalfa	————	98.4	99.9	88	2030
Barley	Six-Row	98.5	97.9	83	240
	Six-Row	98.5	98.95	78	75
	————	98	96.71	98	15
Alsike Clover	Choice	90	98.25	85	440
Red Clover	Choice	97	99	88	635
	Globe	99.2	99.78	86	705
White Clover	————	85	96.26	87	2085
Corn	Early Eight-Rowed	98	96.78	97	....
	Early Mastodon	98	99.6	88	....
	King of the Earliest	97	99.74	99	....
	King Philip Red	98	98.9	96	....
	Leaming	99	97.44	96	....
	Pride of the North	99	99.69	99	....
	Red Cob	98	98.68	93	....
	Sanford White	99	99.42	96	....
Millet	Japanese	98	99.96	95	805
Oats	Pennant	99.5	98.54	99	585
	Pennant	...	99.9	99	15
	White	98.5	99.9	99	30
Rye	Spring	99.5	99.5	98	1090
Timothy	Pine Tree	96	99.04	98	....
BARBER & BENNETT, ARCH AND CHURCH STS., ALBANY, N. Y.					
Alsike Clover	————	97.5	99.63	86	350
Red Clover	————	99	98.05	95	....
	————	99	99.83	96	180
	————	98	98.3	95	1590
Millet	Japanese	99.54	99.98	87	270
Rape	————	99	98.43	96	75
Redtop	Fancy	91.25	88.53	63	120000
BARRETT CO., MANCHESTER, N. H.					
Red Clover	Ace	98	98	76	6426
Timothy	Durham	99.5	99.3	92	*725
JOSEPH BRECK & SONS CORPORATION, 51-52 NORTH MARKET ST., BOSTON, MASS.					
Alsike Clover	Ace	97	97.65	86	5815
	Breck	99	98.97	90	....
Millet	Hungarian	...	99.95	74	1045
	Japanese	98	99.88	97	1870
	Japanese	98	99.87	95	1710
	Japanese	...	99.9	90	1605
Rye	Winter	98.9	98.22	98	....

*225 ergoted seed per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
BURLINGTON GROCERY CO., BURLINGTON, VT.					
Wheat	Spring	99	99.36	95	....
	———	...	99.26	97	15
BURDITT BROS., RUTLAND, VT.					
Alfalfa	———	99.75	99.87	85	....
CHAMPLAIN SEED CO., BURLINGTON, VT.					
Corn	Burlington Dent	95	99.14	95	....
	Early Eight-Row	90	99.75	98	....
	Local Sanford	95	99.36	94	....
	Pride of Michigan	90	99.6	98	....
	Rhode Island Sanford	90	98.58	96	....
E. W. CONKLIN & SON, 28-48 MONTGOMERY ST., BINGHAMTON, N. Y.					
Alfalfa	IXL	99.85	99.99	82	....
Barley	Oderbrucker	99.11	99.43	97	....
	Oderbrucker	96.9	96.89	98	60
Alsike Clover	E. M.	95	99.7	90	900
	Imperial	99.1	99.6	92	1565
	Imperial	98.1	99.45	92	445
	Imperial	97.5	99.96	91	875
Red Clover	Crown	99.35	99.72	98	340
	Crown	99.35	99.53	88	1690
	Paragon	98.25	99.2	88	4040
	IXL	...	99.9	95	445
Corn	Eureka Ensilage	98.9	99.22	97	....
	Leaming	98.86	100	94	....
	Pride of the North	98.9	99.02	98	....
	Sanford White	99.26	97.93	98	....
Millet	Choice German	98.9	99.94	98	2355
	Hungarian	97	99.86	44	2010
	Japanese	97	99	89	2470
Oats	Northern Wonder	98.41	99.65	92	540
	Northern Wonder	97.8	98.4	96	270
	Northern Wonder	97.5	97.33	93	75
Redtop	Imperial	93	92.29	22	1830
	No. 1	93	88.66	25*	17770
	No. 1	92.6	92.25	41*	34460
Timothy	Acme	99.8	99.3	95	1140
	Arrow	99.1	98.75	97	....
	King	99.6	99.6	94	1770
Field Peas	No. 1	93	98.97	100	....
	White-Eye Merrill	98.16	100	80	....

*Claimed by shippers to be old seed; that they have not shipped this brand for two years.

CHARLES M. COX CO., CHAMBER OF COMMERCE, BOSTON, MASS.

Oats	———	90	98.52	96	120

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
CRAVER-DICKINSON SEED CO., 329-351 GANSON ST., BUFFALO, N. Y.					
Field Peas	———	99	98.36	93	....
	———	...	97.16	95	....
E. CROSBY & CO., BRATTLEBORO, VT.					
Oats	Crosby's Recleaned	99.78	99.16	90	105
	Illinois Berry	99.78	99.47	97	75
S. P. CURTIS & SON, RUTLAND, VT.					
Red Clover	Medium	98.75	99.65	88	*1165
DADANT & SONS, HAMILTON, ILL.					
Sweet Clover	Scorefine	88	99.77	89	†720
ALBERT DICKINSON CO., CHICAGO, ILL.					
Alfalfa	Globe	99.85	99.98	93	....
	Grimm	99.9	99.95	91	....
	Pine Tree	98	99.98	83	....
Barley	Ace	98	98.47	99	15
	Six-Row	99	98.09	88	....
	Six-Row	98.5	99.04	81	45
	Six-Row	98	98.77	98	30
	Six-Row	97	97.67	88	....
	Six-Row	96.46	97.69	100	....
	A-260	99	98.99	100	....
Alsike Clover	Ace	95.15	99.48	93	660
	Ace	94	99.48	82	7560
	Ace	93.7	99.1	88	1350
	Ace	92.14	98.05	82	1115
	Globe	99.3	99.5	86	214
	Globe	99	99.15	90	1335
	Globe	98	99.45	87	445
	Kaiser	91	94.45	83	10080
	Pine Tree	96.3	99.66	87	2145
	Queen	98.84	91	74	40310
	Queen	95.02	99.6	81	1102
	86651	95.6	99.3	93	4275
	86685	91.34	97.3	83	3930
Red Clover	Ace	99	99.85	92	‡730
	Ace	98.31	99.63	88	890
	Ace	98	98.7	91	¶5975
	Ace	...	97.3	90	4245

*Russian thistle, 90 per pound. †Russian thistle, 270 per pound. ‡Russian thistle, 430 per pound. ¶Russian thistle, 270 per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
	ALBERT DICKINSON CO. (CONTINUED)				
Red Clover	Globe	99.5	99.72	94	700
	Globe	99.15	99.27	94	560
	Globe	99	99.83	88	420
	Mammoth	99	97.37	91	1040
	Medium	95	97.96	55	7380
	Pine Tree	98.7	99.1	86	2420
	Pine Tree	98.6	99.82	93	175
	Pine Tree	98.5	99.84	93	....
	Pine Tree	97.86	98.87	89	2495
	_____	98.5	99.27	86	2105
	_____	97	98.4	79	3675
	_____	95.02	99.64	79	3240
	_____	...	99.7	83	805
Corn	Early Yellow Dent	99	98.7	96	....
	Eureka	99	99.92	97	....
	Improved Leaming	99	98.12	96	....
	Leaming Fodder	99	100	97	....
	Pride of the North	99	99.57	97	....
	Red Cob	99	99.58	98	....
	Sanford Flint	99	98.81	99	....
	Sanford White	99	98.37	92	....
	Southern White	99	99.5	97	....
Millet	German	98.9	99.96	74	810
	German	98.3	99.96	75	990
	Hungarian	99	99.98	89	180
	Hungarian	98.8	99.95	86	1635
	Japanese	98.6	99.94	98	1440
	Japanese	98.33	99.96	99	1145
	Japanese	98	99.92	99	1620
	Japanese	97.5	99.91	74	1855
	Japanese	97	99.88	93	2555
Redtop	Fancy	92	92.9	30	*10640
	Ace	90.1	89.67	30	†12730
	Ace (recleaned)	90	90.2	44	4805
	Unhulled XX	52.88	51.97	18	20735
Field Peas	_____	99	100	93	....
	Pine Tree	...	96.51	92	....
Timothy	Bison	97	98	90	3135
	Durham	99.5	99.9	93	225
	Globe	99.85	99.75	97	445
	Globe	99.8	99.9	93	575
	Globe	99.75	99.2	96	1125
	Globe	99.7	99.85	98	225
	Pine Tree	99.6	99.5	96	§900
	Pine Tree	99.5	99.65	96	450
	Pine Tree	99	99.65	93	....
	Pine Tree	97	99.2	93	670
	White Pine	96	98.7	99	450
	60642	99.1	99.1	93	7515
Wheat	Spring	98	98.95	94	74

*1702 ergot. †878 ergot. §450 ergoted seed per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
THOMAS W. EMERSON, BOSTON, MASS.					
Corn	Eureka	90	98.58	97	....
	Eureka	...	98.09	95	....
	Pride of the North	...	96.67	100	....
Millet	Hungarian	...	99.9	38	2660
	Japanese	98	99.87	70	3510
FEDERAL MILLING CO., LOCKPORT, N. Y.					
Wheat	Spring	...	94.22	55	60
	Winter	...	92.69	32	165
H. G. FOLSOM, ST. ALBANS, VT.					
Timothy	Monadnock	90	99.56	78.	1255
HALF CENTURY STORE CO., RANDOLPH, VT.					
Timothy	Half Century	99.7	99.11	96	....
E. E. HARRIS, MORRISVILLE, VT.					
Timothy	Green Mountain	99.5	99.94	97	265
HOLBROOK GROCERY CO., KEENE, N. H.					
Alfalfa	Monadnock	90	99.56	78	1255
	White Mountain	98.75	99.93	93	....
Barley	Monadnock	97	98.28	97	....
Buckwheat	————	...	97.47	80	990
Alsike Clover	White Mountain	98.5	99.4	93	640
	White Mountain	84	95.4	75	2260
	X	70	84	51	11750
	XX	80	91.5	66	12090
	XX	84	93.95	83	6905
Red Clover	White Mountain	99.5	99.73	95	260
	White Mountain	99.5	99.82	96	435
	White Mountain XXX	97	98.25	88	1370
	X	80	91.72	77	15500
	XX	95	95.98	89	3115
	XXX	97	98.58	80	3905
	————	95	99.5	89	4725
White Clover	XXX	73.5	98.25	79	4170
Corn	Leaming	97.5	99.1	18	....
	Leaming Fodder	99	98.21	98	....
	Sanford White	92	99.41	99	....

‡14253 ergot. ¶6990 ergot.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
HOLBROOK GROCERY CO. (CONTINUED)					
Millet	Hungarian	97	99.94	74	1046
	Japanese	90	98.48	95	12366
	———	89	94.97	85	11140
Field Peas	———	98	98.7	98	....
Redtop	———	95	95.38	51	14190
	Monadnock	92.16	93.19	39	‡29320
	White Mountain	80	83.89	40	¶131940
Rye	Spring, White Mountain	98.5	99.29	94	†75
Timothy	Pine Tree	99.5	99.85	96	....
	White Mountain	99.7	99.4	81	670
	White Mountain XX	98	98.45	91	2025
	White Mountain XXX	99.6	98.54	99	1550
	X	95	96.5	90	*15075
	X	93	93.5	78	¶3500
	XX	98.92	99.25	91	2240
Wheat	Spring	99	97.21	86	390
E. T. & H. K. IDE, ST. JOHNSBURY, VT.					
Barley	Two-Row	99	98.3	96	60
Red Clover	———	98.85	99.66	84	1030
Millet	Japanese	98	99.96	98	702
Oats	———	98	99.44	89	15
Rape	———	99	99.94	98	....
Rye	Spring	99	93.33	91	....
Timothy	———	99.5	99.55	98	....
	———	99.45	98.9	74	890
INTERNATIONAL CONSOLIDATED RECORD ASSO., ELMIRA, N. Y.					
Corn	Grand Champion	95	99.01	95	....
	Sweepstake Pedi'd Sweet	...	97.09	98	....
W. B. JOHNSON & CO., ESSEX JUNCTION, VT.					
Corn	Early Dent	99.8	99.9	99	....
Oats	Johnson's Fancy	99.25	99.86	98	....
Timothy	———	99.08	99	87	1345
J. W. JONES & CO., BURLINGTON, VT.					
Red Clover	Eureka	98	99.67	99	805
LAPELLE POULTRY FOOD CO., SWANTON, VT.					
Corn	Red Cob	97	98.39	96	....

‡14253 ergot. ¶6990 ergot. *1575 ergot per pound. †30 ergoted grains per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
A. B. LYMAN, EXCELSIOR, MINN.					
Alfalfa	Grimm	95	99.94	92	....
L. L. MARSH, ENOSBURG FALLS, VT.					
Oats	Marsh Perfection	99.34	99.99	93	....
A. H. McLEOD MILLING CO., ST. JOHNSBURY, VT.					
Corn	Longfellow	90	99.28	99	....
Oats	A	98.5	99.69	100	60
Redtop	Eclipse	94.4	97.48	25	§1135
Timothy	Fancy	99.45	99.82	74	670
MICHIGAN SEED CO., RICHFORD, VT.					
Corn	Michigan Dent	100	99.01	99	....
	Minnesota No. 13	99.95	98.91	99	....
	Vermont Dent	90	97.92	98	....
J. O. MIDDLEBROOK & SONS, BURLINGTON, VT.					
Corn	King of the Earliest	95	99.82	98	....
	————	95	99.5	96	....
Rye	Winter	90	95.86	98	15
W. H. MOREHOUSE & CO., 46-47 PRODUCE EXCHANGE, TOLEDO, OHIO					
Alfalfa	Anchor	99	99.93	69	595
Alsike Clover	Anchor	99	98.95	80	670
	Bell	98	98.8	82	1100
	Blue Jay	98.5	99.35	90	445
	X-Ray	93	97	73	900
Red Clover	Bell	98	97.95	89	1610
	X-Ray	92	99.04	92	2690
Corn	Eureka	95	98.7	93	....
	Eureka White	98	97.27	91	....
	Golden Nugget	99	97.62	34	....
	Sanford White Flint	99.5	99.21	96	....
Millet	Hungarian	92	99.97	77	3524
	Japanese	92	99.92	79	2295
Redtop	Fancy	92	92.77	37	19715
Timothy	Anchor	99	99.65	94	655
	Anchor	...	99.65	92	1045
	A	92	92	87	*17840
	Bell	98	99	84	1103
Rye	Winter, Anchor	98	96.98	98	45

§1135 ergot.

*1575 ergot per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
THE PAGE SEED CO., GREENE, N. Y.					
Corn	Early Triumph	90	99.8	98	....
	Early Yellow Canada	96	99.8	98	....
	Page's High Bred Eureka	95	97.92	99	....
	Page's High Leaming	90	98.89	94	....
	Pride of the North	90	99.07	95	....
	Luce's Favorite	90	99.19	94	....
	West Branch	90	99.6	90	....
JEROME B. RICE SEED CO., CAMBRIDGE, N. Y.					
Corn	Leaming	90	96.93	92	....
	Mastodon	90	99.5	94	....
	Ninety-day Dent	90	99.31	97	....
	Early Canada	...	99.5	100	....
	Early Yellow Canada	...	98.13	92	....
	Eureka	...	95.1	94	....
	Leaming	...	95.81	95	....
	Longfellow	...	99.58	96	....
	Red Cob	...	97.73	98	....
	Sanford White	...	97.68	94	....
	Southern White	...	95.4	96	....
	One hundred-day Dent	...	97.49	99	....
	————	...	97.82	95	....
Field Peas	Cambridge	...	97.83	99	....
	————	...	99.29	98	....
ROSS BROS. CO., WORCESTER, MASS.					
Corn	Eureka	90	98.77	94	....
ST. ALBANS GRAIN CO., ST. ALBANS, VT.					
Oats	————	...	94.14	90	*15
W. G. SCARLETT CO., BALTIMORE, MD.					
Soy Beans	Roosevelt	97	97.89	88	....
F. A. SHERMAN, ALBANY, N. Y.					
Corn	Eureka	90	99.1	99	....
	Leaming	90	98.9	99	....
	Pride of the North	90	98.97	97	....
	Stowell's Evergreen	80	99.36	97	....
	————	90	99.11	64	....

*Corn cockle.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
GEO. SHOREY, LYNDONVILLE, VT.					
Oats	———	90	99.61	94	60
H. C. SKEELS, SWANTON, VT.					
Millet	Japanese	97	97.62	99	4540
H. A. SLAYTON & CO., MORRISVILLE, VT.					
Oats	———	...	99.34	97	225
W. H. SMALL & CO., EVANSVILLE, IND.					
Millet	Japanese	...	97.01	16	6220
STANFORD SEED CO., 93 PERRY ST., BUFFALO, N. Y.					
Alfalfa	———	99.5	99.98	89	....
Barley	Six-Row	90	98.66	98	30
Soy Beans	Soy Bean	90	99.99	92	....
Alsike Clover	Fancy	90	96.75	86	330
	———	93.78	99.76	88	21780
Red Clover	Reliable	97.75	99.59	83	980
	———	97.77	99.8	69	350
Corn	Early Triumph	90	98.6	98	....
	Eureka	90	99.33	97	....
	Golden Harvest	90	98.38	78	....
	Imperial Leaming	98.86	98.13	95	....
	Improved Minnesota King	90	99.31	99	....
	Longfellow	90	97.75	88	....
	Northern Wonder	90	97.15	93	....
	Perry's High Bred	90	98.9	92	....
	Pride of Nashua	90	100	92	....
	Sanford White	90	99.14	97	....
	Sweet Corn	95	98.15	97	....
	One hundred-day Dent	90	98.21	97	....
Millet	German	94	99.96	83	90
	Hungarian	97.94	99.97	81	350
	Japanese	96.49	99.74	94	4185
	Japanese	95.67	99.82	93	4935
Oats	Scottish Chief	90	96.9	75	270
	———	90	98.2	91	255
Timothy	Choice	99	99.1	91	3120
	Honor	99.7	99.55	93	450
	Honor	99.7	99.25	91	660
	Liberty	99.5	99.35	89	*445
	Liberty	99.5	99.2	94	†4705
Rape	Dwarf Essex	90	99.92	98	....
	Stanford	90	99.9	91	....
Rye	Winter	90	97.71	86	150

*225 ergot per pound. †675 ergot per pound.

Kind of seed	Trade name	Guaranteed percentage of purity	Actual percentage of purity	Percentage of viability (germination)	Approximate number of weed seeds per pound
W. M. STONE, ATWATER, OHIO					
Soy Beans	Medium Green	90	95.69	75	....
	Roosevelt	90	99.73	99	....
SWEAT-COMINGS, RICHFORD, VT.					
Corn	Leaming Fodder	99	98.96	98	....
WHITNEY-ECKSTEIN SEED CO., 599-601 PERRY ST., BUFFALO, N. Y.					
Alfalfa	Eureka	99.5	99.88	80	860
	———	99.75	99.96	86	150
Barley	Six-Row	98	98.95	99	15
Buckwheat	Buckwheat	99	99.62	98	180
Alsike Clover	Eureka	98.5	98.75	86	670
	Eureka	98.25	99.25	92	1560
	Eureka	98	98.9	90	450
	Pan-American	97	97.3	86	6970
Red Clover	Eureka	99.5	99.98	92	....
	Eureka	99.5	99.52	91	1525
	Eureka	99.4	99.9	93	355
	Eureka	99.25	99.72	90	1535
	Pan-American	98	98.7	90	4850
	Pan-American	97	97.4	96	6150
Corn	Eureka	99.7	97.75	97	....
	Indian	98	99.4	99	....
	Leaming	90	99.14	89	....
	Longfellow	98	99.29	96	....
	Pedigree Leaming	90	100	96	....
	Sanford White	98	98.71	93	....
Millet	German	97	99.96	92	1310
	Hungarian	97	99.99	96	35
	Japanese	94	95.19	96	10790
	Japanese	97	99.84	92	4230
	Japanese	96	99.7	94	6950
Redtop	———	94	95.53	27	3530
	Eureka	94	94.96	18	6730
	———	90	91.98	24	37870
Timothy	Frontier	97	96	95	*13960
	Gold Medal	99.7	99.85	95	...
	Gold Medal	99.7	99.5	92	670
	Gold Medal	99.5	99.58	94	....
	Gold Medal	98.7	99.2	93	....
	Pan-American	99.7	99	93	725
	Pan-American	99.5	99	94	891
	Pan-American	94.5	99.14	99	1070
	———	95.5	98.8	93	1775
Field Peas	———	93	96.29	97	....
	———	...	99.46	95	....
A. H. WINSLOW, BENNINGTON, VT.					
Corn	Longfellow	90	95.56	95	....

*1125 ergot per pound.

VII. CONCERNING THE GERMINATION OF SEED

Last year's bulletin contained a discussion of the weed seed problem. It reviewed the nature of weeds, indicated what makes a plant a weed, and at length and with the aid of 54 illustrations showed what the common weed seeds looked like. A buyer of seed with this bulletin and a magnifying or reading glass in hand can, if he will, make a pretty shrewd estimate of the weed seed contents of any seed which is offered to him. Or, to phrase this matter in another way, the state law, the station inspection service, the descriptions in bulletin 200, a reading glass, and a careful buyer, form a combination which should be of decided help in lessening the numbers of new weeds. If similar precautions had been taken a generation or more ago, provided farmers could have been awakened to the danger, it is not too much to say that paintbrush, daisy, buttercup, wild mustard—yes, perhaps even witchgrass—might have been botanical curiosities. However, it is of little use to cry over weed seeds sown in the past in the place of timothy or clover; but at least we should do what we can to lessen the inflowing stream. And to that end the special article in bulletin 200 was presented.

It seems timely this year to discuss another source of loss incident to the operations of seedtime, namely, the loss due to the use of seed of low viability, and to set forth the manner in which each seed buyer for himself may, if he will, tell whether or not his seed is likely to grow. That there is great variation between seed in this respect is clearly shown in each year's inspection. Thus, for example, in the current year's inspection we find corn when every grain grew and corn when less than one in five grew; millet 99 percent alive and millet 84 percent dead; wheat, 19 of 20 grains of which were capable of growing and wheat which was two-thirds useless.

Now, it has been frequently pointed out that it were fatuous to lock up the garage after a thief had run off with the Ford. It is similarly useless to attempt in July to try and piece out a poor stand of clover or to fill in vacant places in the corn. It is on this account that home germination tests are suggested as a means of determining in a roughly accurate way the viability of contemplated seed purchases. And this is something which, if done at all, must be done at home. The Station cannot do it effectively. It has neither time, means, apparatus nor workers. An experiment station cannot do roughly accurate work; it must do exactly accurate work; and exactly accurate germination work is a costly operation and takes from two to four

weeks. Then again, seed is not offered in any considerable quantities on our markets until within a few weeks of the time when it is sown. Obviously, it would be impossible to do this work for our farmers in a large way. Consequently, home testing should be encouraged, and to that end the following brief descriptions of methods of determining seed germination are offered.

Let it be said, furthermore, prior to the outlining of the way in which these tests may be made, that in these battle years it is peculiarly incumbent upon us to see to it that there are no "slackers" in our fields. A corn kernel which germinates but poorly is a slacker. Its service to its country is better fulfilled if it is used as feed instead of seed.

A careful series of trials with some 45,000 ear-test readings made at the Iowa Station in 1910 and 1911 indicated that in testing corn the so-called "sawdust box" and "rag doll" methods were at once effective, simple and inexpensive. The following descriptions, somewhat modified as to phrasing, are taken from the Iowa publication (No. 135).

THE SAWDUST BOX

Any box about three or four inches deep and 30 by 30 inches in size may be used to make a sawdust box tester.

Fill the box about half full of moist white pine sawdust well pressed down so that it will leave a smooth even surface. The sawdust may be put in a gunny sack and set in a tub of warm water for at least an hour (or, better, over night) so that it will be thoroughly moistened before using.

Rule off a piece of good white cloth (sheeting) about the size of the box, checker-board fashion, 2½ inches each way, and number the squares 1, 2, 3 and so on. Place it over the sawdust and tack it to the box at the edges and corners.

Lay out the ears to be tested side by side on a bench, in a rack or on the floor. Remove a kernel from near the butt, another from the middle and another from the tip of each ear; turn each ear over and remove three more kernels from the opposite side in a like manner, taking six kernels in all, thus securing a representative sample from the entire ear. Place the six kernels either at the end of the ear from which they were taken, or directly in the tester box. Be careful that the kernels do not get mixed with the kernels from the ear next to it. After the kernels are removed, boards may be laid over the rows of corn to keep them in place until the results are secured. Place the

kernels from the ear No. 1 in square No. 1; from ear No. 2 in square No. 2, and so on.

Lay a piece of good cloth on top of the kernels and dampen it by sprinkling water over it. Place over this a cloth considerably larger than the box. Fill in on top of this with about two inches of sawdust moistened as above indicated and press it down firmly, folding the edge of the cloth inwards to cover the sawdust. Keep the box in a warm place where it will not freeze. The kernels will germinate in about six days.

Remove the sawdust and cloth covers carefully in order to avoid misplacing the kernels in the squares. Examine them carefully. Discard all ears represented by one or more dead kernels or by kernels which are decidedly weaker than the average in their germination.

This box, as it is made up with the corn in it and ready to be set away for germination, may be described as follows: Two inches of moist sawdust packed in the bottom; the germination cloth (ruled in squares) with the kernels of corn laid upon it; a second moistened cloth spread over this; a third larger cloth covering the under cloth, on which two inches of moist sawdust is packed firmly.

One should be careful:

To soak the sawdust for at least one hour or, better, over night.

To use a good quality of cloth (sheeting).

To leave at least two inches space around the box to prevent freezing and drying.

To rule the cloth off in large squares two and one-half by two and one-half inches.

To refrain from opening the box too soon. The stem sprouts should be at least two inches long.

To discard all ears showing impaired germination.

To empty out and thoroughly to scald sawdust, cloths and box before using it a second time.

THE RAG DOLL

The rag doll is a cheap, convenient and accurate way in which to test seed corn or any agricultural seed.

Secure sheeting of a good quality and tear it into strips from eight to ten inches wide and three to five feet long. If they are to be used much, the edges may be hemmed for the reason that when unrolled the ravelings sometimes disarrange the kernels. Mark each cloth with a heavy pencil lengthwise in the middle and then crosswise,

as shown in the accompanying illustration, making subdivisions about 3 by 4 to 5 inches. Number the squares as indicated.

Moisten a cloth with warm water—not hot—and lay it out on a board of convenient size in front of the ears which are to be tested. Remove six kernels from ear No. 1, one from near the butt, one from the middle and one from near the tip, and similar numbers from similar locations on the opposite side, and place them in square No. 1 in the upper left hand corner of the cloth. Take in similar fashion six kernels from ear No. 2 and place in square No. 2 in the upper right hand corner; and so on. When the cloth has been filled, begin at the upper end (Nos. 1 and 2), and roll it up. If the cloth is properly moistened the kernels should not push out of place. If a small, irregular piece of wood or some other substance is used as a core in rolling, a more uniform germination may be secured. Tie a string rather loosely about the middle of the roll, or, preferably, use a rubber band. Number this roll No. 1. Proceed similarly with roll No. 2 and those following. As many rolls may be used as are necessary to contain the samples which one has to test. From 20 to 50 ears can be tested in each roll, depending upon the length of the cloth.

Place the filled rolls in a bucket of water where they may remain for from 2 to 18 hours, at the convenience of the operator. Pour off the water at the end of this time and turn the bucket, or a common, dry-goods box, up-side-down over the rolls. Lay a couple of small pieces of wood under the rolls and lift one edge of the pail from one-half to one inch in order to afford sufficient ventilation. The kernels should be ready to examine in five days.

Select, first, either roll No. 1 or the last roll filled, depending upon the arrangement of the ears. Unroll it in front of the ears which are represented. Examine all kernels carefully. Discard any ear in which all six kernels are not strong in germination.

For the Rag Doll it may be said:

1. That it is the cheapest tester which can be made.
2. That anyone can make it in a few moments' time.
3. That it is easily made and filled.
4. That corn may be placed in it and the test read approximately as quickly as in any other home-made or purchased tester.
5. That less mould develops in this tester than in any other.
6. That it may be disinfected for mould most easily.
7. That it is very compact and can be readily moved about.
8. That all parts of the kernels, roots, shoots, etc., can be readily seen.

9. That it affords an accurate test as indicated by field results.

In case, instead of ears, various samples of corn sold shelled or otherwise, or other agricultural seed are to be tested, the procedures will naturally be much the same as those above described. If small seed are to be tested, 100 should be used.

In the long series of trials at the Iowa station it was found that at 20 cents an hour for labor it cost 26.7 cents to test 100 ears of corn in the sawdust tester and a little over 18.2 cents in the rag doll; that to secure enough seed ears to plant an acre—all of them of full viability—cost 21.6 cents when the box was used and 14.4 cents when the doll was employed. The box cost perhaps 80 cents, the doll 10 cents. The box is necessarily somewhat heavy and inconvenient; the doll compact and readily carried about.

Are the results accurate? Does it pay to test corn? The Iowa testimony based upon some 45,000 tests, seems worthy of acceptation. It is to the effect that "inexpensive home-made testers gave as accurate a germination test as the manufactured articles which cost many times as much . . . . that the sawdust box gave the most uniformly accurate measure of vitality, as measured by the percent decrease of stand in the field for each increase in the number of dead kernels." It is further emphatic in saying that "testing the vitality of seed corn before planting increased the profits per acre 93.6 percent in 1910 and 85.7 percent in 1911, or an increase of 19.6 bushels in 1910 and 10.1 in 1911."

If one has only a few lots of seed to test or wishes, as he well may, to test seed other than corn, the plate or flower pot saucer methods work well.

THE PLATE METHOD

Take two plates. Place in one a clean, scalded, folded, wet cloth from which the surplus water has been removed by wringing. Place the seed to be tested—usually 100 seed—between the moistened folds, cover with the second plate to hold moisture and exclude light. Moisten the cloth when necessary. Keep in a warm place, at living room temperature where the night temperature will not fall much below 50°. If one wishes to test several lots of seed, this can be done by putting them in separate folds, properly labelled.

THE FLOWER POT SAUCER METHOD

Place a flower pot saucer of porous clay in a larger dish. Add water to the outer dish to about one-half inch the height of the saucer,

through the walls of which sufficient soaking occurs to keep the inner surfaces moist.

Place the seed—usually 100—in the saucer, either on scalded cloth folds, blotting paper or the base saucer. Keep in a warm place. Cloths should not be kept too wet, lest the seed rot, nor too dry, lest germination be retarded.

Under favorable conditions, grass and clover seed begin to sprout in three or four days.

Sprouted seed should be removed daily. The test should be continued for 10 days or longer if conditions are unfavorable.

The seed to be sampled should be thoroughly mixed and the desired number—usually 100—counted out just as they come, without attempt at choice.

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FERTILIZERS

by J. L. HILLS, C. H. JONES and G. F. ANDERSON

CONCERNING FARM MANURES

by R. T. BURDICK

BURLINGTON
FREE PRESS PRINTING COMPANY
1917

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Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

BULLETIN 206: COMMERCIAL FERTILIZERS

By J. L. Hills, C. H. Jones and G. F. Anderson

CONCERNING TILLAGE

By R. T. Burdick

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SUMMARY

II. The state fertilizer law provides that manufacturers shall state on each package the amounts of plant food it contains and shall make good in fact their claims; and it provides further that the Station shall determine whether or not in each instance these claims are made good.

Prior to last year the Stations of the North Atlantic States have established and used trade values in calculating the so-called "valuations." During the past two years, owing to abnormalities in the trade in crude chemicals caused by wartime conditions, no trade values could be determined.

III. Results of inspection. The Station has drawn from dealers' stocks and analyzed 171 licensed brands, the output of 18 companies, all this year's goods. All the licensed brands but five were sampled and analyzed.

1. Quantity of plant food. Eighty-one percent of the brands met their guaranties. A few brands were not as good as they were said to be. The outcome on the whole is a moderately satisfactory one.

2. Quality of plant food. The quality of the crude stock used seemed in the main to be beyond reproach. The organic nitrogen offerings were as a rule satisfactory. About one-third of the brands contained potash. All but four of the 171 brands carried appreciable amounts of mineral as well as of organic forms of nitrogen.

IV. Selling prices. The average selling price was $32.65. No valuation statement can be made this year owing to the anomalous situation now obtaining in the fertilizer trade.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 39 to 45, and 47 to 52.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletin of the Station dealing with commercial fertilizers not only shall furnish the results of the analyses of these goods, but also may afford "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." The annual bulletin issued during the summer discloses the analyses of all the brands collected, shows their composition during the preceding two and the current years,[1] contains a general review of the state trade, makes statements as to the quantity and quality of the plant food sold in the various brands, considers the comparative value of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.[1]

These general matters are reviewed annually. In addition thereto there is presented yearly a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, has been continued for more than a dozen years, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language is used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99, 130, 143 and 154. These glossaries will be added to from time to time in the future whenever necessary. Anyone failing to grasp the meaning of the terms used should get bulletins 99, 130, 143 or 154 (if in print) and make use of their glossaries. They are free for the asking.

The following statement outlines the "features" of the preceding bulletins:

1902. Bulletin 93. *Formulas for lime mixing.*—56 pages. (Out of print).

1903. Bulletin 99. *Vermont's usage of fertilizer. Concerning fertilizer buying. Deficient plant food.*—88 pages. (Out of print).

[1] Omitted in 1916 and 1917 owing to changes in the trade wrought by the war.

1904. Bulletin 108. *Classification of commercial fertilizers sold in Vermont. Farm manures.*—68 pages. (Out of print).

1905. Bulletin 116. *How, when and what to use.*—104 pages. (Out of print).

1906. Bulletin 123. *Concerning the purchase of plant food. The moisture relations of the soil.*—68 pages. (Out of print).

1907. Bulletin 130. *Soil biology in its relation to fertilization.*—144 pages. (Out of print).

1908. Bulletin 135. *A quarter of a century of fertilizer inspection. Soil deterioration and soil humus.*—128 pages. (Out of print).

1909. Bulletin 143. *The service of a fertilizer control. Soil physiography.*—144 pages.

1910. Bulletin 154. *Soil classifications and adaptations.*—112 pages.

1911. Bulletin 160. *Limes and liming.*—144 pages.

1912. Bulletin 165. *A survey of the peat and muck deposits of Vermont.*—104 pages.

1913. Bulletin 173. *The principles of land drainage.*—96 pages.

1914. Bulletin 182. *Concerning irrigation.*—104 pages.

1915. Bulletin 190. *Concerning crop rotation.*—80 pages.

1916. Bulletin 198. *Concerning tillage.*—84 pages.

These were written in 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915 and 1916; but in the main they are quite as applicable to the purchase and use of fertilizers in 1917 and in succeeding years as they were when first issued. The reader of this bulletin who does not own a 143, a 154, a 160, a 165, a 173, a 182, a 190, or a 198, and wants either or all of them, has but to ask to receive. Nos. 93, 99, 108, 116, 123, 130 and 135 are out of print.

Circular 7 on "Plant Food Combinations for Sundry Crops" contains a reprint of the more important formulas, etc., originally issued in bulletin 116.

Circular 10, issued in December, 1915, "Concerning the Use of Commercial Fertilizers in 1916," deals with the changed situation wrought by war conditions and is of service today as well as formerly. It is a 16-page pamphlet and can be had for the asking.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate

ingredients used to manufacture the same, or * * * bone meal, land plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.).

The law provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in water, and of available and total phosphoric acids." (Sec. 4976 P. S. as amended by No. 182 of the Acts of 1912).

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) "* * * shall annually * * * pay * * * a license fee of twenty dollars," which will permit "the sale of one brand of commercial fertilizer which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than one brand, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of one." "The fee (s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S. as amended by No. 169 of the Acts of 1910).

It provides that any person offering unguarantied, over-guarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool-waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the State Treasurer, and for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs. 4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.).

The full text of the law will be furnished on application.

LIST OF LICENSES

The following eighteen companies (or individuals) have paid licenses as required by law on the brands shown in the statements on pages 26 to 33 and in the tables on pages 34 to 43, and in the list of unsampled brands on the bottom of the next page. The sale within state limits of these brands and of these brands only is legal. All

local agents, as well as intending purchasers, are warned against the handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the required license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 92 State St., Boston, Mass.
Armour Fertilizer Works, 930-938 Equitable Building, Baltimore, Md.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 51 Chambers St., New York, N. Y.
Essex Fertilizer Co., 39 North Market St., Boston, Mass.
International Agricultural Corporation, Buffalo Fertilizer Works, 812 Marine Bank Building, Buffalo, N. Y.
Listers' Agricultural Chemical Works, Lister Ave., Newark, N. J.
Lowell Fertilizer Co., 40 North Market St., Boston, Mass.
National Fertilizer Co., 92 State St., Boston, Mass.
New England Fertilizer Co., 40A North Market St., Boston, Mass.
Parmenter & Polsey Fertilizer Co., 41 North Market St., Boston, Mass.
Reading Bone Fertilizer Co., Reading, Penn.
Rogers and Hubbard Co., Middletown, Conn.
F. S. Royster Guano Co., 1604-1614 Munsey Building, Baltimore, Md.
J. W. Sanborn, Pittsfield, N. H.
Sanderson Fertilizer and Chemical Co., Box 172, New Haven, Conn.
Virginia-Carolina Chemical Co., 120 Broadway, New York, N. Y.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 96 towns and villages in Vermont during the spring of 1917 and drew 496 samples from dealers' stocks, representing 171 distinct brands, the output of 18 companies or individuals licensed to sell in Vermont. A sample was secured of every brand which was licensed, except the following:

Bowker Fertilizer Co.'s All Round Fertilizer.

Listers' Agricultural Chemical Works, Special Corn Fertilizer, 1916.

National Fertilizer Co.'s Tobacco Special without Potash.

National Fertilizer Co.'s National Nitrogen Mixture No. 5.

Parmenter & Polsey Fertilizer Co.'s Grain Grower.

In some cases no shipments whatever of these brands appear to have been made, and in the others only very small ones.

CONCERNING TRADE VALUES

It has been customary at this point each year to print the "schedule of trade values" agreed upon by the Experiment stations of New England, New York and New Jersey. These trade values were determined by carefully studying and averaging the prices at which fertilizer crude stock sold in our larger markets, such as New York and Boston, at retail for cash during the six months preceding March 1st. The wholesale prices were also carefully scanned. The system has worked well for a long series of years. Prices of standard goods have fluctuated more or less, but not so much as to prevent averages being struck which were within bounds of reason. Not so, however, in 1916 and 1917. For example, nitrate of soda sold at approximately $45 a ton during the early months of the war; but it rapidly began to slant upwards, was quoted at $49 in August, 1915, at $65 in December, 1915, and was bought delivered at Burlington in small quantities at $80 in 1916. Sulphate of ammonia has increased from about $60 in 1914 to $80 in 1916, and is now almost absolutely out of the market save at prohibitive prices. Everyone knows that beefsteak costs money nowadays and shortage of cattle means shortage of animal ammoniates. Cottonseed meal which is largely used in commercial fertilizer manufacture now sells at more than $50 a ton delivered in Vermont; yet it was quoted at southern shipping points in August, 1915, at $23. Acid phosphate is a luxury. And potash is almost as extinct as the dodo and sells at ten times its former price. Much of this was set forth in circular 10 issued in December, 1915.

It is quite evident that averages cannot be made with safety under such circumstances and that even if an attempt was made to establish trade values they would have no validity in view of the changed conditions now existing. Hence it was that, after careful consideration of the entire matter, it was unanimously voted at the 1916 spring meeting of the directors of the New England, New York and New Jersey stations to establish no trade values for that year, a decision which was ratified by similar action in 1917.

It is realized that some users of commercial fertilizers may miss the ready means of comparison heretofore afforded by the valuation system. If so, they must blame the Teutonic or the Allied governments—according to their predilections—and not the experiment stations.

III. RESULTS OF FERTILIZER INSPECTION

1. AS TO THE QUANTITY OF PLANT FOOD

(a) COMPARISON OF GUARANTIES AND ANALYSES

The quality of the fertilizers sold in Vermont in 1917 by most of the companies seems to have been thoroughly satisfactory; that is to say, manufacturers' promises, whether large or small, with some exceptions have been made good. In view of the difficult situation confronting the manufacturers because of war conditions the maintenance of guaranties by most of the companies has been gratifying. However, it should be said that in a considerable number of cases guaranties have been shaved so closely that the margin of safety has been nearly or quite eliminated. It is of course a great temptation now that crude stock is held at sky high prices to crowd the minimum guaranty.

Now while the above statement holds for the offerings of most of the companies two are in difficulties this year, one actual, the other seemingly apparent. In view of the fact that both have been engaged in the trade for a long series of years and that their goods in the past have been as a general rule thoroughly satisfactory from the standpoint of the enforcement of the law, and since, speaking broadly, the companies in question have not failed in the past to furnish a commercial equivalent of their guaranties, it seems only just to make the following statements. It goes without saying that such a situation is not a pleasant one for manufacturers to meet; yet, on the other hand, it is not one which the Station can fail to disclose.

International Agricultural Corporation, Buffalo Fertilizer Works. Seven of the 15 brands offered were found seriously deficient. Perhaps never before has the Station by resampling and the analyses of other samples done more to check the accuracy of its sampling and analytical procedure. The conclusion to which it has arrived is that serious errors have occurred in the shipping department.

Rogers & Hubbard Co. The samples representing three of the seven brands offered by this company were found considerably deficient in their plant food contents. It is but just to say that the nature of the crude stock used—it is thoroughly good material—in several of their brands is such that their so-called available phosphoric acid contents as determined by the conventional analytical method are more or less a matter of guess work. Two of the three considerable deficiencies are in available phosphoric acid, and in one instance the amount of insoluble phosphoric acid claimed, and doubtless correctly,

by the manufacturer to be of bone origin, is far in excess of the guaranty. Then, furthermore, this company has been using to some extent a relatively new but thoroughly desirable phosphatic crude stock which is of such an extremely fine texture that it tends mechanically to separate from the other ingredients while the mixed goods are in transit and to pass to the outer portions of the sack. The sampling agent usually thrusts the sampling tube throughout the center of the sacks and might under such circumstances draw samples which tended to run low of truth in their phosphoric acid contents.

No trade values having been established for this year, this ready means of reckoning shortages cannot be resorted to. All forms of plant food stand in a sense on a parity, one being as good as another. The few brands decidedly deficient as thus measured lack from ½ to 1½ percents of their promised plant food contents, equivalent to shortages of from 4 to 11 percents of the amounts guarantied. The identity of these brands can be readily determined by reference to the tables of analyses.

However, when all is said and done, faulty fertilizers, as judged by the comparison of promise and performance, are not very common in Vermont. The trade, as a whole, seems to be "as well as could be expected" in view of the abnormal situation now obtaining. Indeed, comparison with the results attained in other states is a favorable one, since the proportion of guaranty maintenance in bygone years seems better in Vermont than that commonly found elsewhere. In normal years commercial fertilizers are shipped into Vermont earlier than into most of the other Northern States. Whether to this fact or to other causes may be attributed the relatively small proportion of failures to furnish the promised plant food which usually obtains here cannot be said; but certain it is that, as judged by several years' control work, the Vermont farmer does not often buy a fertilizer of lower grade than is promised him.

The plant food shortages in the 32 deficients of 1917 were distributed as follows: Nitrogen, 10; available phosphoric acid, 15; potash, 11. Only 15 of the 392 guaranties made on 171 brands by 18 manufacturers, or one in 26, were not made good within 0.50 percent of a single ingredient.

The condensed results of 20 years' inspection of the Vermont trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	92	38	71	94
1906	130	110	20	85	98
1907	129	99	30	77	94
1908	130	92	38	71	95
1909	133	111	22	83	96
1910	152	138	14	91	100
1911	157	146	11	93	99
1912	182	156	26	86	98
1913	177	153	24	86	98
1914	185	153	32	83	97
1915	173	144	29	83	98
1916	168	137	31	82	..
1917	171	139	32	81	..

Whenever guaranties were not made good the analytical work was repeated, and invariably recourse was had to other samples taken a second time from the original shipments, except in cases where the goods had been used prior to the attempt a second time to sample them. It should be remarked, however, that it was more difficult to do this in 1917 than usual, for shipments were belated owing to freight car embargoes and hence samples were drawn and analytical work begun some weeks later than usual. When results seemed open to question, other samples elsewhere drawn were analyzed. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were instituted with a view of minimizing error and standardizing results.

The following table shows the number of brands sold by the different companies licensed in Vermont, the number of guaranties (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good within the tolerance figures long adopted at this Station, namely, 0.10 percent of nitrogen and 0.20 percent of available phosphoric acid or potash.

Name of company	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands deficient in total plant food
American Agricultural Chemical Co.	14	30	0	0
Bradley Fertilizer Co. branch	16	39	2	0
Crocker Fert. and Chem. Co. branch	3	9	0	0
Darling Fertilizer Co. branch	1	3	0	0
Great Eastern Fertilizer Co. branch	3	9	1	0
Pacific Guano Co. branch	4	10	1	0
Quinnipiac Co. branch	2	4	0	0
Read Fertilizer Co. branch	2	6	1	0
Williams & Clark Fertilizer Co. branch	4	10	1	0
American Agricultural Chemical Co.—Total	49	120	6	0
Armour Fertilizer Works	8	22	2	1
Bowker Fertilizer Co.	18	41	2	0
Burlington Rendering Co.	6	12	0	0
Coe-Mortimer Co.	9	22	0	0
Essex Fertilizer Co.	4	8	2	1
International Agricultural Corporation, Buffalo Fertilizer Works	15	39	9	5
Listers' Agricultural Chemical Works	8	20	1	0
Lowell Fertilizer Co.	7	14	3	2
National Fertilizer Co.	5	13	1	0
New England Fertilizer Co.	5	10	3	1
Parmenter and Polsey Fertilizer Co.	4	8	1	1
Reading Bone Fertilizer Co.	7	15	0	0
Rogers and Hubbard Co.	7	15	5	4
F. S. Royster Guano Co.	7	18	0	0
J. W. Sanborn	3	6	0	0
Sanderson Fertilizer and Chemical Co.	3	9	0	0
Virginia-Carolina Chemical Co.	6	15	1	0
Total	171	407	36	15

Twelve of the 18 companies contribute brands to the delinquent list. Five furnish a single branch each; three, 2; and four, 3, 5, 6 and 7 brands respectively.

The range of composition and the closeness with which guaranties are met are displayed in the following table. The condition of affairs it discloses, a close hugging of the guaranties, has obtained for years, as appears in the lower half of the table, which shows the excess of the average analysis over the average guaranty for each of five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average only about five percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

MAINTENANCE OF GUARANTIES BY LICENSEES

	PERCENT GUARANTIED			PERCENT FOUND			Excess of average analysis over guaranty
	Lowest	Highest	Average	Lowest	Highest	Average	
Nitrogen	0.82	8.23	2.30	0.98	8.46	2.55	0.25
Total phosphoric acid	6.	14.	10.28	7.08	17.08	11.39	1.11
Available phosphoric acid	5.	13.	9.28	5.94	12.75	9.71	0.43
Potash	0.	4.	0.55	0.	3.81	0.52	—0.03
Selling price	$22.50	$59.50	$32.65				

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSES OVER GUARANTIES

	1913	1914	1915	1916	1917	Av'ge for 5 years
Nitrogen	0.20	0.17	0.31	0.18	0.25	0.22
Total phosphoric acid	0.82	0.85	0.89	0.80	1.11	0.90
Available phosphoric acid	0.41	0.44	0.53	0.41	0.43	0.44
Potash	0.54	0.29	0.14	—0.02	—0.03	0.18
Valuation	$1.90	$1.35	$1.36	....	....	....

While the above statement shows that the goods compare well on the average with the claims made for them, the tables on pages 34 to 43, and 46 to 52, as well as the statements on pages 11-12, betray the fact that within this average lie concealed several deficiencies. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guarantied is not furnished to know that the "average" is good. It is for him to exercise care and avoid buying such goods.

(*b*) COMPARATIVE VALUES OF FERTILIZERS IN 1916 AND 1917

It has been customary at this point in the annual fertilizer bulletin to compare averages. Thus in 1914 at this point it was said that "of the 193 brands of commercial fertilizers which were sampled by the Station during 1913 and 1914, 169 have been selected for the purpose of instituting a comparison of the characters of the goods sold under these brand names in each of the two years. Only those brands have been chosen which have been sampled both years." No such comparison can be made this year. Manufacturers were forced in 1915 by the potash situation decidedly to modify many of their brands as to their guaranties; in 1916 yet further changes had to be made; and in 1917

yet others. Many of the manufacturers have used new brand names or those used prior to 1915 slightly modified to meet this unprecedented situation. Others have sold their goods with the same old brand names, but with changed guaranties. It should be distinctly understood that this latter procedure is no crime, since the law does not and cannot control as to names. A manufacturer may, if he wishes, sell one year a high grade product named, let us say, Smith's Mighty Melon Maker, and the next year, using precisely the same brand name, sell the lowest of the low grades. *Caveat emptor;* it is for the buyer to beware, to watch guaranties and to buy accordingly.

The following statement is believed accurately to set forth the 1917 practice of the Vermont licensees insofar as it pertains to sales in this State.

New brand names used:

Armour Fertilizer Works,
F. G. Royster Guano Co.,
Virginia-Carolina Chemical Company.

***"1916" placed after and made a part of each brand name,* in order to distinguish it as a formula unlike that used in ante-bellum times; or, in some cases, new brand names:**

American Agricultural Chemical Company,
Bowker Fertilizer Company,
Coe-Mortimer Company,
Listers' Agricultural Chemical Works,
National Fertilizer Company,
Sanderson Fertilizer and Chemical Company.

Former brand names used on most or all of the goods, which often are quite unlike those heretofore sold under the same brand names:

Burlington Rendering Company,
Essex Fertilizer Company,
International Agricultural Corporation, Buffalo Fertilizer Works,
Lowell Fertilizer Company,
New England Fertilizer Company,
Parmenter and Polsey Fertilizer Company,
Reading Bone Fertilizer Company,
Rogers and Hubbard Company,
J. W. Sanborn.

A few typical examples of sales of brands similarly named but diversely guaranteed are shown herewith:

					VEGETABLE					
'14	guaranty:	2.46%	nitrogen;	7%	available	phosphoric	acid;	10%	potash	
'15	"	3.28%	"	8%	"	"	"	4%	"	
'16-'17	"	4.1%	"	10%	"	"	"	0	"	
					TOPDRESSING					
'14	guaranty:	5.7%	nitrogen;	6%	available	phosphoric	acid;	5%	potash	
'15	"	5.8%	"	6%	"	"	"	2%	"	
'16-'17	"	5.8%	"	6%	"	"	"	0	"	
					POTATO AND TOBACCO					
'14	guaranty:	0.82%	nitrogen;	6%	available	phosphoric	acid;	7%	potash	
'15	"	0.82%	"	6%	"	"	"	4%	"	
'16-'17	"	0.82%	"	12%	"	"	"	0	"	
					OATS AND TOPDRESSING					
'14	guaranty:	8.5%	nitrogen;	4.5%	available	phosphoric	acid;	8%	potash	
'15	"	8.5%	"	4.5%	"	"	"	4%	"	
'16-'17	"	6%	"	6%	"	"	"	0	"	
					POTATOES AND CORN					
'14	guaranty:	3.3%	nitrogen;	7%	available	phosphoric	acid;	8%	potash	
'15	"	3.3%	"	8%	"	"	"	4%	"	
'16-'17	"	3.3%	"	8%	"	"	"	0	"	

Let it be said again, it is no crime thus to modify formulas; but the ethics of such a procedure is open to question. The writer is frank to say that he believes that brand names ought to be altered whenever formulas are materially modified, that it is at once the honest and the expedient thing to do. Shakespeare's query "What's in a name" has pertinence in this connection. The writer is not unmindful of the present dire straits of the trade, that plant food and bags to ship it in are hard to get; but he thinks that a name should mean something.

(*c*) COMPARATIVE VALUE OF FERTILIZERS FROM 1898 TO 1917

The next table shows the average composition of the fertilizers as analyzed during the last 20 years. Every brand tested each year is included in the comparison, each one being given equal value. It is well understood that this is not strictly a correct method of calculation, but it is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods in the past have sold slowly, and, unfortunately, low grade brands as a rule readily, the actual average as used is probably somewhat lower than that shown in the table. Yet the evidence in hand indicates a rapidly lessening usage of low grades and a larger usage of medium and high grades.

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1897 TO 1916

Year	Number of brands	Nitrogen	PHOSPHORIC ACID					Potash	Average ton selling price	Valuation each year's trade values	Selling price exceeds valuation	Selling price exceeds valuation, (percent)	Value of plant food received for a dollar (cts.)
			Soluble	Reverted	Insoluble	Total	Available						
1898	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81	$29.04	$17.86	$11.18	63	61
1899	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10	28.75	17.39	11.36	65	60
1900	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80	28.73	18.08	10.65	59	63
1901	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33	28.75	19.44	9.31	48	68
1902	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21	28.23	20.18	8.05	40	71
1903	111	2.02	5.13	3.42	2.50	11.05	8.55	3.79	28.25	18.59	9.66	52	66
1904	118	1.98	5.20	3.19	2.38	10.77	8.39	3.95	29.00	18.47	10.53	57	64
1905	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18	29.62	19.04	10.58	56	64
1906	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37	29.52	19.38	10.14	52	66
1907	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65	30.57	21.21	9.36	45	69
1908	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58	31.24	20.75	10.49	51	66
1909	133	2.08	5.25	3.07	2.21	10.53	8.32	4.70	31.43	18.84	12.59	67	60
1910	152	2.12	5.50	2.86	1.53	9.89	8.36	4.99	31.45	20.57	10.88	53	65
1911	157	2.06	5.69	2.60	1.56	9.85	8.29	4.94	31.41	19.53	11.88	61	62
1912	182	2.19	4.99	2.92	1.75	9.66	7.91	5.55	32.03	20.09	11.94	59	63
1913	177	2.37	4.69	3.16	1.37	9.21	7.84	5.96	32.64	21.24	11.40	54	65
1914	185	2.32	4.68	3.19	1.51	9.38	7.87	5.77	32.53	20.35	12.18	60	63
1915	173	2.48	4.81	3.85	1.43	10.09	8.66	3.00	33.06	20.64	12.42	60	59
1916	168	2.61	5.12	4.42	1.40	10.94	9.54	0.55	33.88	....	....	..	..
1917	171	2.55	5.15	4.46	1.68	11.39	9.71	0.52	32.65	....	....	..	..

It ought to be remarked at this point that neither this table, nor this discussion which accompanies it, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made a dozen or more years ago to estimate the relative usage of the different grades, but without much success. No data are available that are trustworthy, while if one appeals to the individual judgment of those who are in close touch with the trade the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used during the years immediately preceding 1915 at approximately 2.1 percent nitrogen, 8.5 percent available phosphoric acid, and 3.7 to 4 percent potash; in 1915 at approximately 2.3 percent nitrogen, 8.7 percent available phosphoric acid, and 2.5 percent potash; in 1916 and 1917 at approximately 2.5 percent nitrogen, 9.5 percent available phosphoric acid and 0.50 percent of potash.

The average commercial fertilizer sold in Vermont in 1914 contains 0.25 percent more nitrogen, 0.50 percent less available phosphoric acid and a percent more potash than the average sold in the decade previous to 1912; the 1915 goods as compared with 1914's average were

0.2 percent higher in nitrogen, 0.8 percent higher in available phosphoric acid and 2.8 percent lower in potash; the 1916 goods were increased yet more, 0.1 percent in nitrogen and 0.9 percent in available phosphoric acid over the 1915 goods, and contained but one-sixth as much potash; and the 1917 goods average much as did those sold last year. Indeed, as compared with the average goods sold in 1912 to 1914 those now offered contain one-eighth more nitrogen and one-fifth more available phosphoric acid; but as an offset to these increments they contain less than one-tenth as much potash.

The increase in the average of the ten years, 1905-1914, as compared with those of previous years is due to the high grade of certain goods sold for the first time in 1905, and to the entry in each of several years since, and especially during 1912-1914, of a number of very high grade goods. This change in average quality was doubtless more apparent than real, for the newcomers inevitably are not at the outset as widely sold as are the old-timers. A survey of the last table indicates that prior to the war there has been on the whole an up-grading in the character of the goods used by Vermont farmers. Indeed there seem to be periods of 6, 7 and 3 years respectively, wherein there are to be found somewhat wide variations in the plant food contents of the average goods, particularly in phosphoric acid and potash, as is shown in the following table:

1899-04	nitrogen 2.07, available phosphoric acid 8.51, potash 4.06
1905-11	nitrogen 2.08, available phosphoric acid 8.25, potash 4.63
1912-14	nitrogen 2.29, available phosphoric acid 7.87, potash 5.76
1915	nitrogen 2.48, available phosphoric acid 8.66, potash 3.00
1916-17	nitrogen 2.58, available phosphoric acid 9.62, potash 0.54

2. As to Quality of Plant Food

SOURCES OF PLANT FOOD IN LICENSED FERTILIZERS

The table on page 15 as well as those on pages 34 to 43 show wide ranges in composition, amounts of nitrogen varying from 0.91 to 8.46 percent, of available phosphoric acid from 5.94 to 12.75 percent, and of potash from zero to 3.81 percent. These figures alone, however, do not tell the whole story or, indeed, much of the story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food purveyed in the various brands is derived.

NITROGEN

In all but four of the 171 brands, nitrogen as nitrate of soda or sulphate of ammonia was present in appreciable amounts. Doubtless the fact that mineral nitrogen is now more plentiful than is organic nitrogen explains somewhat its freer usage. Time was, not long ago, when the ratio of mineral to organic nitrogen was much less than it is today in the goods sold in Vermont, and when a large share of the brands contained neither nitrate nor ammonia salts. The amounts found in this year's goods vary from 0.07 to 6.59 percent, averaging 1.30 percent or 51 percent of the total nitrogen present in the brands carrying this ingredient, a very different situation than formerly obtained. Under certain circumstances and for certain purposes mineral nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available but is more easily lost by leaching. Speaking broadly, however, the presence of mineral nitrogen in commercial fertilizers is to be favored for most of the purposes for which such goods are used in Vermont. It is an open question, however, whether manufacturers are not going too far in this matter. Fifty to 70 percent of nitrogen in mineral forms in some seasons may be a somewhat larger proportion than can be used to good advantage. An over-supply may be present at the outset and, following heavy rains, an under-supply during late July and August; yet on the other hand it is but fair to admit that manufacturers are often at their wit's end in attempting to secure an adequate supply of organic nitrogen of good grade. The usage of commercial fertilizers in this country is increasing by leaps and bounds. In 1900, 2,200,000 tons were produced; in 1913, more than 6,800,000 tons; and the increased crop acreage of 1915 doubtless absorbed fully 7,500,000 tons. Yet in the face of this situation the supply of many forms of organic nitrogen is shrinking both relatively and actually. Just what will happen a decade hence, just what manufacturers and farmers will do for organic nitrogen, is not easy to predict. However, thanks to the modern methods of gathering nitrogen from the air agriculture will not lack for combined nitrogen unless it be that the munitions trade absorbs an undue proportion.

All the brands which carry nitrogen contain more or less organic nitrogen, derived doubtless as a rule from standard animal and vegetable ammoniates or from lower grades of ammoniates so processed as to be made relatively available.

AVAILABILITY OF ORGANIC NITROGEN

In the tables of analyses on pages 34 to 43, appear tabulated data setting forth the character of the organic nitrogen used in the various brands offered for sale, with a view of indicating its serviceability to crop growth. This Station for 20 years has thus "kept tab" on the quality of the organic nitrogen which was used in the several brands offered for sale. Long before it seemed advisable to print its analytical results it formed an opinion in many instances of the character of the organic nitrogen used in the fertilizers sold to Vermont farmers. It did not hesitate by correspondence and by personal interview to question the character of the organic nitrogen used in certain brands, and in times past not infrequently found that its queries were justified by facts, either directly acknowledged or at least not gainsaid by the manufacturers. Its long experience with the alkaline permanganate method of determining organic nitrogen availability, the long series of analytical results accumulated in its files for a score of years, the work done by other stations in this section of the country using the same method, have served to give confidence in the essential accuracy of its findings.

The nitrogen contents of a fertilizer are now stated in the analytical tables on pages 34 to 43 in the following terms: Nitrogen in nitrates; nitrogen in ammonia salts; water soluble organic nitrogen; insoluble organic nitrogen; total nitrogen.

1. *Nitrogen in nitrates.* The percentage of nitrogen derived from nitrate of soda, a soluble mineral form of nitrogen immediately available to plant growth.

2. *Nitrogen in ammonia salts.* The percentage of nitrogen derived from sulphate of ammonia, a high grade gas-house or coke-oven by-product or, perhaps, in part from cyanamid; a mineral form of nitrogen readily available to plant growth.

3. *Water soluble organic nitrogen.* The percentage of nitrogen derived from organic sources—or, perhaps, in part from cyanamid—which is soluble in water. The presumption is that most organic nitrogen soluble in water is likely on that account to be relatively available to plant growth.

4. *Insoluble organic nitrogen.* The percentage of such organic nitrogen as is not soluble in water.

The quality of the water insoluble organic nitrogen in the 171 brands has been found to be entirely satisfactory in nine-tenths of the cases. However, the alkaline permanganate method indicated the use

of inferior sources of organic nitrogen in 16 cases. In all but four of these, however, the readily available nitrogen constitutes so large a proportion of the total that no mention need be made concerning them.

The four samples which contain excessive amounts of organic nitrogen of relatively inferior quality are:

Armour Fertilizer Works. D. 2. One-Eight-Two. Contains 49 percent of the guaranteed nitrogen, or 54 percent of the total nitrogen found, in unavailable forms.

Armour Fertilizer Works. D. 4. Grain Grower. Contains 42 percent of its nitrogen in unavailable forms.

Royster Guano Co. H 7. Cuckoo Crop Grower. Contains 49 percent of the guaranteed nitrogen, or 65 percent of the total nitrogen present, in unavailable forms.

Sanderson Fertilizer and Chemical Co. B 15. Potato Manure. Contains 74 percent of the total nitrogen present in unavailable forms.

PHOSPHORIC ACID

Some companies furnish more total phosphoric acid in available form than do others; some, more of the water soluble relative to the citrate soluble or reverted than do others. Water soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumina phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as serviceable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 54 percent to 95 percent. The proportions of available phosphoric acid found to be in a water soluble form varied from one to 81 percent. Grouped according to their manufacture it was found that extremes for available in total were 66 and 91 percents, for water soluble in available 31 and 70 percents. In other words the average goods made by one firm carried 91 percent of the total phosphoric acid in available form, while those made by another firm furnished but 66 percent in that shape, the remainder ranging between. Similarly, on the average 70 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 31 percent was thus soluble in the average goods of another firm. The low availability seems to be due in certain cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause,

to imperfectly cut phosphate rock, to the age of the goods, to over-usage of ground limestone as a dryer or conditioner, to the use of agriculturally inferior forms of phosphoric acid or to other causes does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, very rarely, nitrate. Practically sulphate of potash had not entered into the Vermont fertilizer trade until war conditions made muriate a rarity. The asterisk (*), dagger (†) or double dagger (‡) appear in connection with the potash figures when sulphate of potash is found to be present; where these signs do not appear, the potash was derived from muriate or kainit, or else a sufficiency of chlorin was present in other combinations to mask the presence of sulphate and entirely to nullify its good effects, if any such there be.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for 20 years; but for the reasons set forth on page 10 such a relationship cannot now be established. However, some statements may be made as to the relative costs.

The brands may be classified as to selling prices as follows:

	Number of brands	Percentage of total	Average selling price
Low priced, selling at $31 or below.....	79	46	$27.63
Medium priced, selling from $31.50 to $34.50	44	25	33.01
High priced, selling for $35 or more.....	48	29	40.56

What have fertilizers cost during this year of stress as compared with previous years, when conditions were normal?

The following table sets forth this situation:

	Average	Low priced	Medium priced	High priced
Selling price 1914	$32.53	$26.08	$30.64	$39.66
Selling price 1915	33.06	26.46	31.84	40.35
Selling price 1916	33.88	28.42	33.00	39.84
Selling price 1917	32.65	27.63	33.01	40.56
Increase or decrease 1915 over 1914	+0.53	+0.38	+1.20	+0.69
Increase or decrease 1916 over 1914	+1.35	+2.34	+2.36	+0.18
Increase or decrease 1917 over 1914	+0.12	+1.55	+2.37	+0.90

It appears:

1. That the average 1915 goods cost a half dollar, the average 1916 goods nearly $1.50 and the average 1917 goods only 12 cents more than the average ante-bellum fertilizer.

2. That the lower grades cost but little more in 1915 than in 1914 but that their price was raised nearly $2.50 in 1916 and $1.50 in 1917.

3. That the medium priced brands were increased in price about $1.25 in 1915 and almost as much more in 1916 and 1917.

4. That the high priced fertilizers were increased about 75 cents in 1915 and nearly a dollar this year. However, these goods suffered much more than did their weaker sisters in their quality debasement caused by the shortage of potash.

How was the potash distributed in the 1917 goods?

Low priced	79 brands	20 contained 1 percent	25 percent
Medium priced	44 brands	19 contained 1 percent and 2, 2 percent	47 percent
High priced	48 brands	11 contained 1 percent and 13 contained from 2 to 4 percent	50 percent

A fourth of the lower grades, nearly half the medium grades and half the higher grades carried potash.

The 1917 goods sold in Vermont were, so far as their potash contents are concerned, of three sorts. A little more than one-fourth of them contained one percent of potash; nearly two-thirds carried no potash whatever; and about one-twelfth were guaranteed to carry two to four percent of this rare ingredient. It is a pertinent question to ask what manufacturers charged for potash. Exact comparisons are not possible, because fertilizers cost more at some points in Vermont than at others, owing to differences in freight rates; but, speaking broadly, it seems safe to say that it cost from 15 to 20 cents a pound.

The proportion of the lower priced brands to the total was larger in 1917 than heretofore. Nearly half the total number offered sold at $31 or less a ton. This is a larger proportion than has been found for several years. In former years and normal times the writer has deplored the sale of low grades; but these are abnormal times and he is not inclined to murmur at this present tendency. Moreover, nearly three-fifths of last year's brands contained one percent of potash and the presence of this one percent added from $3 to $5 to the cost of the goods. This year, as has just been pointed out, less than one-third of the goods contain one percent of potash, almost two-thirds contain no potash, and about one-twelfth contain from two to four

percent. The smaller proportion of goods containing this costly ingredient accounts in large measure for the lessened average price and the marked change in the distribution of the grades. It is a desirable change. One percent of potash at $5 is a delusion and a snare.

ELEMENTS DETERMINING THE PRICE OF A COMMERCIAL FERTILIZER

Many elements enter into the determination of the cost of a commercial fertilizer as it is usually bought by the farmer from a local dealer in relatively small amounts and on time. They include:

1. *Assembling.* The original wholesale cost of the crude stocks or ingredients to the manufacturer, who secures nitrate of soda from Chili, potash salts from Germany, pyrites from Spain or brimstone from Louisiana, phosphate rock from Florida, South Carolina or Tennessee, sulphate of ammonia from Europe or from various points in this country, organic ammoniates from all sorts and conditions of places, from near at hand and from the ends of the earth. This original cost must of course cover the cost of mining and manufacture, of freightage to the factory and the overhead charges incident to manufacture, shipping and jobbing.

2. *Mixing.* The cost of mixing, including the manufacture of sulphuric acid, the expense of grinding phosphate rock, bones, etc., the commingling in the requisite proportions of the several ingredients, their storage until dry, their regrinding, bagging and loading.

3. *Mixing.* The overhead cost on the charges which are necessarily connected with the assembling and the mixing of the plant food, covering such items as interest on investment, insurance, taxes, depreciation of the manufacturing plant, certain office charges, etc.

4. *Transportation.* Freightage from factory to railroad station.

5. *Selling.* The overhead costs and charges inevitably connected with the sale of mixed fertilizers, covering such items as commissions to agents and dealers, interest charges on long credits, bad debts, advertising, and, finally, profits.

V. OBSERVANCE OF THE FERTILIZER LAW

LIST OF LICENSED COMMERCIAL FERTILIZERS

The following companies have paid licenses on the 171 brands specified on this and the next few pages, being the entire number of licensed brands save the five listed on page 9 which were not found on sale by the station sampling agents. This list also shows the names

and addresses of the parties from whose stocks the samples were drawn and the laboratory sample numbers referring to the analyses on pages 34 to 43.

AMERICAN AGRICULTURAL CHEMICAL COMPANY, 92 State St., Boston, Mass.

J 12 *AA Potato Grower, 1916;* J. H. Peters, North Bennington.
C 1 *Ammoniated Fertilizer A;* B. G. Brown, Jericho.
C 2 *Ammoniated Fertilizer AA;* C. I. Sheldon, Rupert.
C 3 *Ammoniated Fertilizer AAA;* H. K. Westall, Richmond.
C 4 *Ammoniated Fertilizer AAAA;* E. W. Rice, Bennington.
C 6 *Cereal and Root Fertilizer;* Oliva Phoenix, Swanton.
K 2 *Extra Quality Potato Manure;* E. B. Leland, North Springfield.
E 6 *General Crop Grower, 1916;* W. B. Ladd, Enosburg Falls.
C 7 *Grain and Seeding Fertilizer;* Alex. Peltier, Highgate.
J 11 *Grass and Lawn Top Dressing, 1916;* Berry & Jones, Motpelier.
H 1 *High Grade Fertilizer, 1916;* A. B. Weeks, North Clarendon.
C 5 *High Grade Grass Top Dressing without Potash;* J. H. Peters, North Bennington.
L 10 *Odorless Grass and Lawn Top Dressing without Potash;* Robbins & Cowles, Brattleboro.
E 5 *Special Vegetable Fertilizer;* C. M. White, Woodstock.

(Bradley Fertilizer Co. brands)

J 8 *Complete Manure for Potatoes and Vegetables;* J. L. Putney, Woodstock.
B 5 *Corn Phosphate, 1916;* J. O. Middlebrook & Sons, Burlington.
A 2 *Eclipse Phosphate, 1916;* Berry & Jones, Montpelier.
A 3 *General Fertilizer;* Berry & Jones, Montpelier.
C 9 *Grain Fertilizer;* E. J. Davis, Chester Depot.
C 8 *Maine Potato Special;* Jasper E. Foster, Underhill.
A 1 *Potato Fertilizer, 1916;* Berry & Jones, Montpelier.
C 11 *Potato Manure, 1916;* J. A. Graham, Bethel.
B 7 *Root Crop Manure;* J. O. Middlebrook & Sons, Burlington.
A 4 *Special Corn Phosphate without Potash;* Berry & Jones, Montpelier.
C 10 *Special Potato Fertilizer without Potash;* R. C. Lampman, Pownal Center.
C 12 *Special Potato Manure without Potash;* W. C. Marsh, Sheldon.
B 6 *Special XL Superphosphate without Potash;* R. C. Lampman, Pownal Center.

J 10 *Three Star Special with Potash;* E. S. Devine, Northfield.
B 4 *Universal Crop Phosphate;* Wm. Place, Essex Junction.
A 5 *XL Superphosphate of Lime, 1916;* Berry & Jones, Montpelier.

(Crocker Fertilizer and Chemical Co. brands)

E 8 *Ammoniated Corn Phosphate, 1916;* F. C. Harvey, East Burke.
E 10 *New Rival Corn Superphosphate, 1916;* Varney Bros., Bristol.
E 9 *Potato, Hop and Tobacco Fertilizer, 1916;* F. C. Harvey, East Burke.

(Darling Fertilizer Co. brand)

E 11 *General Fertilizer, 1916;* [lost freight], St. Albans.

(Great Eastern Fertilizer Co. brands)

C 13 *General, 1916;* H. M. Brown, Castleton.
E 13 *Northern Corn Special, 1916;* H. E. Currier, Concord.
E 12 *Potato Manure, 1916;* H. E. Currier, Concord.

(Pacific Guano Co. brands)

K 14 *Nobsque Guano, 1916;* W. F. Buckland, Derby Center.
C 14 *Special Potato Fertilizer without Potash;* W. R. White, North Bennington.
J 16 *Soluble Pacific Guano, 1916;* F. L. Ayer, Windsor.
K 13 *Special Soluble Pacific Guano without Potash;* C. C. Ingram, South Newfane.

(Quinnipiac Co. brands)

E 15 *Special Corn Manure without Potash;* A. C. Larrabee, Enosburg Falls.
C 15 *Special Potato Phosphate without Potash;* L. J. Mills, Groton.

(Read Fertilizer Co. brands)

J 13 *Farmers' Friend Superphosphate, 1916;* Oliva Phoenix, Swanton.
D 1 *Practical Fertilizer, 1916;* Oliva Phoenix, Swanton.

(Williams and Clark Fertilizer Co. brands)

H 4 *Americus Corn Phosphate, 1916;* R. R. Sherman, Tinmouth.
L 4 *Americus Potato Manure, 1916;* C. A. Chapman, Ferrisburg.
L 3 *Special Americus Corn Phosphate without Potash;* F. M. Abbott, St. Johnsbury.
C 16 *Special Americus Potato Manure without Potash;* Half Century Store Co., Randolph.

ARMOUR FERTILIZER WORKS, 930-938 Equitable Bldg., Baltimore, Md.

L 7 *Five-Eight-Four;* E. I. Benson, Woodstock.
E 2 *Four-Eight-Zero;* E. A. Ferguson, Bristol.
D 4 *Grain Grower;* F. S. Blossom, Bethel.
D 2 *One-Eight-Two;* H. P. Munson & Co., Morrisville.
L 12 *Two-Eight-One;* E. I. Benson, Woodstock.
E 3 *Two-Eight-Three;* E. I. Benson, Woodstock.
E 1 *Two-Eleven-Zero;* H. L. Baker, Springfield.
D 3 *Wheat, Corn and Oats Special;* F. S. Blossom, Bethel.

BOWKER FERTILIZER CO., 43 Chatham St., Boston, Mass.

K 5 *Brighton Phosphate;* B. C. Miles, Glover.
B 3 *Corn Phosphate, 1916;* O. S. Howard, South Barre.
K 3 *Five-Eight General Crop;* H. E. Bond, Westminster.
E 7 *Five-Ten Early Crop;* Charles H. Abell, Enosburg Falls.
J 15 *Four-Ten Hill and Drill;* Charles H. Abell, Enosburg Falls.
H 2 *High Nitrogen Mixture, 1916, without Potash;* A. B. Weeks, North Clarendon.
D 6 *One-Ten Sure Crop;* N. N. Morse & Son, Randolph.
B 2 *Potato Phosphate, 1916;* Kempton Mills, Barre.
B 1 *Stockbridge Cereal Manure without Potash, 1916;* C. H. Post, Essex Junction.
L 5 *Stockbridge General Crop Manure, 1916;* F. T. Phelps, Essex Junction.
K 6 *Superphosphate with Ammonia, 1%;* B. C. Miles, Glover.
D 5 *Superphosphate with Ammonia, 2%;* P. Dutton, Poultney.
K 4 *Superphosphate with Ammonia, 3%;* E. A. Dana, North Pomfret.
J 6 *Sure Crop Phosphate, 1916;* Kempton Mills, Barre.
H 3 *Three-Ten All Round;* A. B. Weeks, North Clarendon.
D 7 *Two-Ten Corn;* J. D. Maker, Newfane.
J 7 *Two-Ten Farm and Garden;* N. N. Morse & Sons, Randolph.
D 8 *Two-Ten Potato;* A. N. Washburn, Bethel.

BURLINGTON RENDERING CO., North Ave., Burlington, Vt.

D 10 *Animal Fertilizer;* H. C. Skeels & Co., Swanton.
B 8 *Grain Fertilizer;* R. L. Clark, Barre.
K 8 *Grass Fertilizer;* F. Wilson, Newport.
B 9 *Potato Fertilizer;* R. L. Clark, Barre.

D 9 *Special Fertilizer;* A. W. Clark, Marshfield.
K 1 *Vegetable Fertilizer;* J. W. Jones & Co., Burlington.

THE COE-MORTIMER CO., 51 Chambers St., New York, N. Y.

D 12 *E. Frank Coe's Columbian Corn and Potato Fertilizer, 1916;* C. Peckham, Pownal Center.
D 14 *E. Frank Coe's Gold Brand Excelsior Guano, 1916;* Wm. Waterman, South Royalton.
D 15 *E. Frank Coe's High Grade Ammoniated Superphosphate, 1916;* A. Batchelder, Plainfield.
D 13 *E. Frank Coe's New Englander Special, 1916;* N. E. Fairchild, Bethel.
A 7 *E. Frank Coe's Original Ammoniated Dissolved Phosphate, 1916;* M. A. Nelson, Montpelier.
J 5 *E. Frank Coe's Prolific Crop Producer, 1916;* M. A. Nelson, Montpelier.
D 11 *E. Frank Coe's Standard Potato Fertilizer, 1916;* Wm. Carter, Swanton.
A 6 *E. Frank Coe's Top Dressing Manure, 1916;* M. A. Nelson, Montplier.
D 16 *E. Frank Coe's XXV Ammoniated Phosphate, 1916;* E. Lanou, North Rupert.

ESSEX FERTILIZER CO., 39 North Market St., Boston, Mass.

B 10 *Grain, Grass and Potato Fertilizer;* J. O. Middlebrook & Sons, Burlington.
B 11 *Market Garden and Potato Manure;* F. L. Sargent, East Barre.
B 12 *Potato, Corn and Vegetable;* J. O. Middlebrook & Sons, Burlington.
B 13 *XXX Fish Fertilizer;* F. L. Sargent, East Barre.

INTERNATIONAL AGRICULTURAL CORPORATION,
BUFFALO FERTILIZER WORKS, 812 Marine Bank Bldg., Buffalo, N. Y.

J 1 *Buffalo Ammoniated Phosphate;* A. St. Francis, Derby Center.
H 16 *Buffalo Economy;* H. E. Currier, Concord.
F 2 *Buffalo Farmers' Choice;* M. A. Bullock, Jericho.
H 15 *Buffalo General Favorite;* Edward Foss, Plainfield.
F 5 *Buffalo High Grade Manure;* Edward Foss, Plainfield.
F 3 *Buffalo New England Special;* C. S. Goodrich, Richmond.

L 8 *Buffalo Potato and Corn;* L. Niles, Pownal.
A 8 *Buffalo Potash Special;* M. A. Nelson, Montpelier.
H 14 *Buffalo Potato and Truck Manure;* A. L. Carpenter, Essex Junction.
F 1 *Buffalo Standard;* Story Bros., St. Albans.
J 2 *Buffalo Superior Fertilizer;* Aplin & Bugbee, Putney.
L 8 *Buffalo Tiptop;* L. Niles, Pownal.
A 9 *Buffalo Top Dresser;* M. A. Nelson, Montpelier.
F 6 *Buffalo Triumph;* Edward Foss, Plainfield.
F 4 *Buffalo Vegetable and Potato;* W. B. Ladd, Enosburg Falls.

LISTERS' AGRICULTURAL CHEMICAL WORKS, Lister Ave., Newark, N. J.

A 12 *Crescent Ammoniated Superphosphate, 1916;* M. A. Nelson, Montpelier.
A 10 *Excelsior Guano, 1916;* M. A. Nelson, Montpelier.
J 3 *Grain and Grass Fertilizer, 1916;* Jesse Smith, Lyndonville.
G 14 *Potato Manure, 1916;* H. O. Holt & Co., Richford.
G 15 *Revised Vermont Corn and Potato Fertilizer;* Joseph Taylor, Barnet.
J 4 *Special Potato Fertilizer with Potash, 1916;* H. O. Holt & Co., Richford.
G 16 *Success Fertilizer, 1916;* H. O. Holt & Co., Richford.
A 11 *Superior Ammoniated Superphosphate, 1916;* M. A. Nelson, Montpelier.

LOWELL FERTILIZER CO., 40 North Market St., Boston, Mass.

G 7 *Animal Brand for All Crops;* City Feed Co., St. Albans.
G 11 *Bone Fertilizer for Corn, Grain, Grass and Vegetables;* S. P. Curtis & Son, Rutland.
G 10 *Empress Brand for Corn, Potatoes and Grain;* H. W. Myers & Co., Bennington.
G 12 *Potato Manure;* J. D. Maker, Newfane.
G 9 *Potato, Corn and Vegetable;* J. F. Devon, Cambridge.
G 8 *Potato Phosphate;* C. H. Post, Essex Junction.
G 13 *Sterling Phosphate;* Fowler Feed Co., North Troy.

NATIONAL FERTILIZER CO., 92 State St., Boston, Mass.

K 9 *Eureka Potato Fertilizer, 1916;* H. A. Whitcomb, Norwich.
K 11 *Nitrogen Phosphate Mixture No. 3;* H. A. Burnham, Norwich.

K 12 *Nitrogen Phosphate Mixture No. 4;* Geo. I. Fellows, Guildhall.
L 6 *Potato Phosphate;* O. A. Cobb, Bridgewater.
K 10 *Universal Grain and Potato Fertilizer;* Geo. I. Fellows, Guildhall.

NEW ENGLAND FERTILIZER Co., 40A North Market St., Boston, Mass.

F 11 *Corn and Grain Fertilizer;* W. D. Stimson, Wells River.
F 8 *Corn Phosphate;* W. F. Sinclair, Johnson.
F 9 *Potato Fertilizer;* Joseph Huntley, Norwich.
F 7 *Potato, Corn and Vegetable;* —— Ricky, Barre.
F 10 *Superphosphate for All Crops;* C. N. Boise, Poultney.

PARMENTER & POLSEY FERTILIZER Co., 41 North Market St., Boston, Mass.

E 16 *Corn and Grain Fertilizer;* R. M. Steele, Barnet.
H 13 *Plymouth Rock Brand Fertilizer for All Crops;* R. M. Steele, Barnet.
L 9 *Potato Fertilizer;* W. E. Pierce, Cuttingsville.
H 12 *Potato Phosphate;* N. H. Duba, Highgate.

READING BONE FERTILIZER Co., Reading, Pa.

F 13 *Reading All Crop Special;* L. Bryant, South Troy.
F 12 *Farmers' Tankage and Potash for Corn, Grain and Grass;* J. R. Clark, Rupert.
A 13 *Never Fail Crop Grower;* Fred A. Hills, Montpelier.
F 15 *Reading Prize Winner;* K. Marsh, North Bennington.
F 16 *Reading Special Grain and Grass Producer;* J. T. Hazen, Norwich.
F 14 *Reading Special Potato and Tobacco Manure;* J. R. Clark, Rupert.
K 15 *Truck, Fruit, Tree, Vine, Potato and Tobacco Grower;* Chas. Dutchburn, Richford.

ROGERS & HUBBARD Co., Middletown, Conn.

G 5 *All Soils—All Crops Phosphate;* E. Marsh, Sheldon.
G 6 *Complete Phosphate;* H. Abbott, Northfield.
G 3 *"Bone Base" Oats and Topdressing;* Rex Fullam, East Fairfield.
G 2 *"Bone Base" Soluble Potato Manure;* Rex Fullam, East Fairfield.

G 1 *"Bone Base" Soluble Corn and General Crops Manure;* Rex Fullam, East Fairfield.

J 9 *Randolph Potato Growers' Special;* E. S. Tewksbury & Co., Randolph.

G 4 *Potato Phosphate;* E. S. Tewksbury & Co., Randolph.

F. S. ROYSTER GUANO Co., 1604-1614 Munsey Bldg., Baltimore, Md.

H 7 *Cuckoo Crop Grower;* B. F. Crippen, Castleton.

B 16 *Curfew Ammoniated Superphosphate;* Don Camp, South Barre.

H 6 *Dreadnaught Fertilizer;* B. F. Crippen, Castleton.

J 14 *Innovation Ammoniated Superphosphate;* A. J. Clark, Sutton.

K 7 *Logical Compound;* H. C. Royce & Co., Sheldon Springs.

E 14 *Penguin Ammoniated Superphosphate;* Don Camp, South Barre.

H 5 *Utopia Compound;* B. F. Crippen, Castleton.

J. W. SANBORN, Pittsfield, N. H.

H 11 *Prof. Sanborn's Chemical Fertilizer for Grass and Grain;* E. G. Plummer, South Ryegate.

H 9 *Prof. Sanborn's Chemical Fertilizer for Use in Hill and Drill;* R. D. Page, Plainfield.

H 10 *Prof. Sanborn's Chemical Fertilizer for Potatoes and Corn;* E. G. Plummer, South Ryegate.

SANDERSON FERTILIZER AND CHEMICAL Co., Box 172, New Haven, Conn.

H 8 *Atlantic Coast, Bone, Fish and Potash, 1916;* R. Bartlett, Shelburne.

B 14 *Corn Superphosphate, 1916;* C. B. Goodrich, Richmond.

B 15 *Potato Manure, 1916;* Timothy Collins, Richmond.

VIRGINIA-CAROLINA CHEMICAL Co., 120 Broadway, New York, N. Y.

A 15 *Ammoniated Bone Phosphate for All Crops;* Charles Duberry, Montpelier.

A 16 *Beef, Blood and Bone BBB (with 3 Percent Potash);* Charles Duberry, Montpelier.

K 16 *Beef, Blood and Bone BBB (without Potash);* C. E. Marshall, West Burke.

L 1 *Twentieth Century Potato Manure (with 2 Percent Potash);* Walker & Brock, Barnet.

PLATE I—HOW NOT TO DO IT

The preventable annual losses in Vermont amount to much more than Vermont's investment in Liberty Bonds.

PLATE II—HOW NOT TO DO IT

Carriers cannot conserve carelessly covered collections. Loose lying lots lead to leaching and loss.

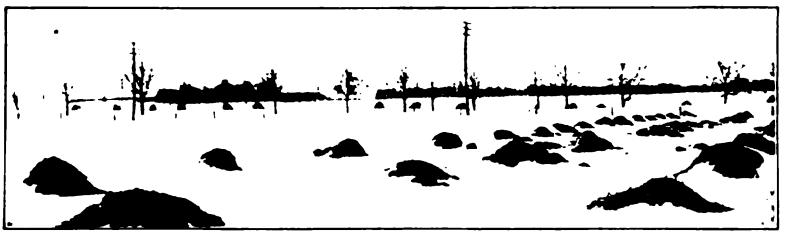

PLATE III—CAUSE AND EFFECT

FIGURE 1—A good arrangement for checkers, but a bad one for manure. Expensive in time and labor. See result, Figure 2.

FIGURE 2—A patchy, uneven stand of grass, due to the localization of the plant food. See cause, Figure 1.

PLATE IV—HOW TO DO IT

FIGURE 1—Spreading manure on the snow is a safe and advisable practice on reasonably level areas and gets it where it belongs.

FIGURE 2—A well made, compact, steep manure pile, concaved on top (not shown in picture). A good method of temporary storage of manure.

Plates I to IV are loaned by the Wisconsin Station, for which courtesy the Station is indebted.

L 2 Twentieth Century Potato Manure (without Potash); N. Graham, Highgate Center.

A 14 XXXX Fish and Potash Mixture; Charles Duberry, Montpelier.

CONCERNING THE TABLES ON PAGES 34 TO 43

These tables, from the point of view of the execution of the law, form the essential part of the bulletin. Therein are displayed side by side what the fertilizer manufacturer says he will furnish and what he does furnish, the one in *italics,* the other in **black face.** Furthermore all the details are given in order that the buyer may judge not only how much or how little plant food he gets for his money but how good or how inferior it is and what parts are good and what less good. While it is doubtless true that most buyers pay no attention to the work of the control, many who have done so have profited thereby in getting a larger return in plant food for a dollar spent as a result of their study of the matter. And in order that such as may wish to grasp the full purport of these tables may be enabled to do so, there has been published from time to time brief explanatory matter, and several years ago, a series of very full, almost painfully full, explanations of the meaning and significance of each piece of data was printed in bulletin 143.

In brief it may be said that the parallel **black face** and *italic* columns are the most serviceable means of comparing promises and actualities so far as the quantity of plant food is concerned; and that the other figures help one to determine more particularly the quality of a given fertilizer.

In this connection attention is called to the explanatory matter on pages 45 and 46 concerning the simplified form of tables dealing with the results of fertilizer inspection, as well as to the tables themselves on pages 47 to 52.

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
J 12	AA Potato Grower, 1916	1.15	1.20	0.45	1.02	**3.82**	*3.7*	3.88	4.90	1.28	**10.06**	*9.*	8.78	*8.*	**1.01**	*1.*
C 1	Ammoniated Fertilizer A	0.43	0.27	0.04	0.35	**1.09**	*0.82*	5.54	4.52	1.10	**11.16**	*11.*	**10.06**	*10.*	...	..
C 2	Ammoniated Fertilizer AA	0.26	0.37	0.52	0.74	**1.89**	*1.65*	4.84	5.74	1.72	**12.30**	*11.*	**10.58**	*10.*	...	..
C 3	Ammoniated Fertilizer AAA	0.91	0.74	0.35	0.63	**2.63**	*2.47*	5.00	5.20	1.80	**12.00**	*11.*	**10.20**	*10.*	...	..
C 4	Ammoniated Fertilizer AAAA	1.15	1.20	0.56	0.56	**3.47**	*3.29*	5.88	3.93	2.00	**11.81**	*11.*	**9.81**	*10.*	...	..
C 6	Cereal and Root Fertilizer	0.92	0.83	0.32	0.60	**2.67**	*2.47*	5.84	4.60	1.30	**11.74**	*11.*	**10.44**	*10.*	...	..
K 2	Extra Quality Potato Manure	1.61	1.55	0.45	0.95	**4.56**	*4.11*	6.72	4.28	1.30	**12.30**	*11.*	**11.00**	*10.*	...	..
E 6	General Crop Grower, 1916	0.51	0.44	0.38	0.56	**1.89**	*1.65*	5.08	5.00	1.20	**11.28**	*10.*	**10.08**	*9.*	**0.86**	*1.*
C 7	Grain and Seeding Fertilizer	0.68	0.41	0.41	0.32	**1.82**	*1.65*	5.32	4.66	1.46	**11.44**	*11.*	**9.98**	*10.*	...	..
J 11	Grass and Lawn Top Dressing, 1916	1.24	1.25	0.42	0.95	**3.86**	*3.7*	3.40	5.54	1.46	**10.40**	*9.*	**8.94**	*8.*	**0.98**	*1.*
H 1	High Grade Fertilizer, 1916	0.70	0.70	0.50	0.70	**2.60**	*2.47*	4.78	4.48	1.90	**11.16**	*10.*	**9.26**	*9.*	**0.91**	*1.*
C 5	High Gr. Grass Topdr. without Potash	3.49	1.91	0.74	0.56	**6.70**	*6.58*	5.02	3.00	1.00	**9.02**	*9.*	**8.02**	*8.*	...	..
L 10	Odorless Gr. & Lawn Topdr. without Pot.	0.57	1.41	2.37	0.56	**4.91**	*4.11*	5.26	4.77	0.62	**10.65**	*11.*	**10.03**	*10.*	...	..
E 5	Special Vegetable Fertilizer	1.15	1.20	0.60	0.56	**3.51**	*3.29*	5.80	4.06	2.60	**12.46**	*11.*	**9.86**	*10.*	...	..
	(Bradley Fertilizer Co. Brands)															
J 8	Compl. Manure for Potatoes & Veg., 1916	1.09	0.98	0.38	0.88	**3.33**	*3.29*	4.64	4.50	1.38	**10.52**	*10.*	**9.14**	*9.*	**0.99**	*1.*
B 5	Corn Phosphate, 1916	0.33	0.48	0.45	0.77	**2.03**	*1.65*	6.96	3.76	1.06	**11.78**	*11.*	**10.72**	*10.*	**0.78**	*1.*
A 2	Eclipse Phosphate, 1916	0.49	0.35	0.28	0.46	**1.58**	*1.23*	4.04	6.24	1.41	**11.69**	*11.*	**10.28**	*10.*	**0.81**	*1.*
A' 3	General Fertilizer	0.71	0.62	0.07	0.53	**1.93**	*1.65*	6.50	3.52	0.85	**10.87**	*11.*	**10.02**	*10.*	...	..

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.—Cont.															
	(*Bradley Fertilizer Co. Brands*)—Cont.															
C 9	Grain Fertilizer	0.38	0.32	0.10	0.25	**1.05**	*0.82*	5.48	4.50	0.74	**10.72**	*11.*	**9.98**	*10.*	...	..
C 8	Maine Potato Special	1.68	1.44	0.32	0.77	**4.21**	*4.11*	6.16	3.88	1.00	**11.04**	*11.*	**10.04**	*10.*	...	..
A 1	Potato Fertilizer, 1916	0.64	0.69	0.53	0.67	**2.53**	*2.06*	3.78	5.02	1.64	**10.44**	*9.*	**8.80**	*8.*	**0.83**	*1.*
C 11	Potato Manure, 1916	0.82	0.72	0.46	0.67	**2.67**	*2.47*	4.10	5.14	1.40	**10.64**	*10.*	**9.24**	*9.*	**0.91**	*1.*
B 7	Root Crop Manure	0.20	1.69	0.32	1.23	**3.44**	*3.29*	7.24	3.05	1.15	**11.44**	*11.*	**10.29**	*10.*	...	..
A 4	Special Corn Phosphate without Potash.	0.61	0.51	0.21	0.42	**1.75**	*1.65*	5.80	4.43	0.77	**11.00**	*11.*	**10.23**	*10.*	...	..
C 10	Special Potato Fertilizer without Potash.	0.67	0.56	0.31	0.35	**1.89**	*1.65*	6.12	4.24	1.26	**11.62**	*11.*	**10.36**	*10.*	...	..
C 12	Special Potato Manure without Potash...	0.96	0.79	0.43	0.49	**2.67**	*2.47*	6.08	3.86	2.06	**12.00**	*11.*	**9.94**	*10.*	...	..
B 6	Special XL Superphosphate without Pot.	0.91	0.84	0.43	0.56	**2.74**	*2.47*	5.52	4.53	1.29	**11.34**	*11.*	**10.05**	*10.*	...	..
J 10	Three Star Special with Potash.....	0.89	0.90	0.28	0.63	**2.70**	*2.47*	5.32	4.62	0.72	**10.66**	*9.*	**9.94**	*8.*	**2.74**	*3.*
B 4	Universal Crop Phosphate	0.91	0.84	0.35	0.60	**2.70**	*2.47*	5.36	4.64	1.34	**11.34**	*11.*	**10.00**	*10.*	...	..
A 5	XL Superphosphate of Lime, 1916	0.19	0.79	1.02	0.67	**2.67**	*2.47*	3.66	5.45	1.49	**10.60**	*10.*	**9.11**	*9.*	**0.93**	*1.*
	(*Crocker Fertilizer & Chemical Co. Brands*)															
E 8	Ammoniated Corn Phosphate, 1916.....	0.66	0.74	0.49	0.53	**2.42**	*2.06*	3.72	5.36	1.86	**10.94**	*9.*	**9.08**	*8.*	**0.88**	*1.*
E 10	New Rival Ammoniated Superphos., 1916	0.19	0.13	0.34	0.39	**1.05**	*0.82*	5.90	5.33	1.13	**12.36**	*11.*	**11.23**	*10.*	**0.90**	*1.*
E 9	Potato, Hop and Tobacco Fertilizer, 1916.	0.72	0.58	0.31	0.56	**2.17**	*2.06*	5.60	5.08	1.02	**11.70**	*11.*	**10.68**	*10.*	**0.96**	*1.*
	(*Darling Fertilizer Co. Brand*)															
E 11	General Fertilizer, 1916	...	0.09	0.58	0.42	**1.09**	*0.82*	4.96	4.98	1.52	**11.46**	*9.*	**9.94**	*8.*	†**0.91**	*1.*

†Half or more as sulphate.

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.—Cont.															
	(Great Eastern Fertilizer Co. Brands)															
C 13	General, 1916	0.49	0.56	0.35	0.49	**1.89**	*0.82*	3.92	5.20	1.80	**10.92**	*9.*	**9.12**	*8.*	**0.74**	*1.*
E 13	Northern Corn Special, 1916	0.81	0.84	0.42	0.60	**2.67**	*2.06*	3.68	4.97	2.07	**10.72**	*9.*	**8.65**	*8.*	**0.94**	*1.*
E 12	Potato Manure, 1916	0.70	0.63	0.25	0.63	**2.21**	*2.06*	5.04	5.22	1.14	**11.40**	*11.*	**10.26**	*10.*	**0.98**	*1.*
	(Pacific Guano Co. Brands)															
K 14	Nobsque Guano, 1916	0.28	0.32	0.41	0.39	**1.40**	*0.82*	4.44	5.86	1.44	**11.74**	*9.*	**10.30**	*8.*	†**0.69**	*1.*
C 14	Special Potato Fertilizer without Potash.	0.74	0.35	0.31	0.46	**1.86**	*1.65*	5.68	4.38	1.90	**11.96**	*11.*	**10.06**	*10.*	...	..
J 16	Soluble Pacific Guano, 1916	0.61	0.51	0.28	0.42	**1.82**	*1.65*	5.92	4.98	1.48	**12.38**	*11.*	**10.90**	*10.*	‡**1.10**	*1.*
K 13	Special Sol. Pacific Guano without Potash	0.67	0.42	0.42	0.35	**1.86**	*1.65*	6.00	4.32	1.70	**12.02**	*11.*	**10.32**	*10.*	...	..
	(Quinnipiac Co. Brands)															
E 15	Special Corn Manure without Potash....	0.59	0.53	0.32	0.42	**1.86**	*1.65*	6.16	4.58	0.88	**11.62**	*11.*	**10.74**	*10.*	...	..
C 15	Special Potato Phosphate without Potash	0.60	0.42	0.34	0.53	**1.89**	*1.65*	3.58	6.42	2.29	**12.29**	*11.*	**10.00**	*10.*	...	..
	(Read Fertilizer Co. Brands)															
J 13	Farmers' Friend Superphosphate, 1916..	0.68	0.65	0.50	0.63	**2.46**	*2.06*	4.00	4.96	1.60	**10.56**	*9.*	**8.96**	*8.*	†**0.82**	*1.*
D 1	Practical Fertilizer, 1916	...	0.25	0.38	0.35	**0.98**	*0.82*	4.24	5.62	1.38	**11.24**	*9.*	**9.86**	*8.*	†**0.70**	*1.*
	(Williams & Clark Fertilizer Co. Brands)															
H 4	Americus Corn Phosphate, 1916	0.68	0.51	0.28	0.42	**1.89**	*1.65*	5.84	4.26	1.66	**11.76**	*11.*	**10.10**	*10.*	†**1.06**	*1.*
L 4	Americus Potato Manure, 1916	0.66	0.74	0.32	0.67	**2.39**	*2.06*	3.84	5.43	1.47	**10.74**	*9.*	**9.27**	*8.*	†**0.82**	*1.*
L 3	Special Americus Corn Phos. without Pot.	0.60	0.49	0.27	0.60	**1.96**	*1.65*	3.80	5.86	2.82	**12.48**	*11.*	**9.66**	*10.*	...	..
C 16	Spec. Americus Potato Man. without Pot.	0.70	0.56	0.24	0.39	**1.89**	*1.65*	5.64	4.59	1.17	**11.40**	*11.*	**10.23**	*10.*	...	..

†Half or more as sulphate. ‡From a fourth to a third (approximately) as sulphate.

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Armour Fertilizer Works															
L 7	Five-Eight-Four	1.05	0.46	0.59	2.21	**4.31**	*4.11*	4.22	3.66	2.17	**10.05**	*8.5*	**7.88**	*8.*	**3.81**	*4.*
E 2	Four-Eight-Zero	...	1.09	0.44	1.47	**3.00**	*3.29*	5.96	1.80	1.26	**9.02**	*8.5*	**7.76**	*8.*	...	..
D 4	Grain Grower	0.49	0.32	0.14	0.70	**1.65**	*1.65*	3.28	4.67	0.93	**8.88**	*8.5*	**7.95**	*8.*	**2.02**	*2.*
D 2	One-Eight-Two	...	0.23	0.19	0.49	**0.91**	*0.82*	3.44	5.08	1.20	**9.72**	*8.5*	**8.52**	*8.*	†**1.80**	*2.*
L 12	Two-Eight-One	0.29	0.20	0.21	1.02	**1.72**	*1.65*	3.32	4.68	1.02	**9.02**	*8.5*	**8.00**	*8.*	**1.10**	*1.*
E 3	Two-Eight-Three	0.38	0.18	0.28	0.91	**1.75**	*1.65*	3.92	4.11	1.45	**9.48**	*8.5*	**8.03**	*8.*	**2.95**	*3.*
E 1	Two-Eleven-Zero	...	0.49	0.38	1.02	**1.89**	*1.65*	9.00	2.08	1.96	**13.04**	*11.5*	**11.08**	*11.*	...	..
D 3	Wheat, Corn and Oats Special	....	0.07	0.21	0.63	**0.91**	*0.82*	4.64	2.40	0.72	**7.76**	*7.5*	**7.04**	*7.*	†**1.02**	*1.*
	Bowker Fertilizer Co.															
K 5	Brighton Phosphate	...	0.27	0.43	0.35	**1.05**	*0.82*	4.74	5.80	1.34	**11.88**	*9.*	**10.54**	*8.*	**0.71**	*1.*
B 3	Corn Phosphate, 1916	0.59	0.46	0.17	0.60	**1.82**	*1.65*	5.64	5.05	1.07	**11.76**	*11.*	**10.69**	*10.*	**1.01**	*1.*
K 3	Five-Eight General Crop	0.84	1.48	0.87	1.30	**4.49**	*4.11*	4.92	3.49	1.75	**10.16**	*9.*	**8.41**	*8.*	...	..
E 7	Five-Ten Early Crop	1.63	1.53	0.31	0.88	**4.35**	*4.11*	5.92	4.10	1.54	**11.56**	*11.*	**10.02**	*10.*	...	..
J 15	Four-Ten Hill and Drill	1.21	1.11	0.52	0.67	**3.51**	*3.29*	5.82	4.22	1.76	**11.80**	*11.*	**10.04**	*10.*	...	..
H 2	High Nitrogen Mixture, 1916, without Pot.	3.57	3.02	0.82	1.05	**8.46**	*8.23*	3.62	2.32	1.14	**7.08**	*6.*	**5.94**	*5.*	...	..
D 6	One-Ten Sure Crop	0.39	0.21	0.17	0.28	**1.05**	*0.82*	5.90	4.72	1.26	**11.88**	*11.*	**10.62**	*10.*	...	..
B 2	Potato Phosphate, 1916	0.49	0.49	0.35	0.60	**1.93**	*1.65*	5.86	4.33	1.35	**11.54**	*11.*	**10.19**	*10.*	**0.98**	*1.*
B 1	Stockbridge Cereal Man. without Pot., '16	1.08	1.16	0.57	0.63	**3.44**	*3.29*	5.84	4.27	2.29	**12.40**	*11.*	**10.11**	*10.*	...	..
L 5	Stockbridge General Crop Manure, 1916..	1.13	1.04	0.25	0.88	**3.30**	*3.29*	4.62	4.89	1.35	**10.86**	*10.*	**9.51**	*9.*	†**1.04**	*1.*
K 6	Superphosphate with Ammonia, 1%	0.42	0.25	0.21	0.21	**1.09**	*0.82*	6.48	4.98	0.90	**12.36**	*11.*	**11.46**	*10.*	...	..

†Half or more as sulphate.

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Bowker Fertilizer Co.—Cont.															
D 5	Superphosphate with Ammonia, 2%	...	0.56	0.35	0.88	**1.79**	*1.65*	4.52	5.05	2.23	**11.80**	*11.*	**9.57**	*10.*	...	..
K 4	Superphosphate with Ammonia, 3%	0.96	0.79	0.32	0.56	**2.63**	*2.47*	5.60	4.49	1.07	**11.16**	*11.*	**10.09**	*10.*	...	..
J 6	Sure Crop Phosphate, 1916.....	...	0.16	0.58	0.35	**1.09**	*0.82*	5.80	5.29	1.69	**12.78**	*11.*	**11.09**	*10.*	†**0.95**	*1.*
H 3	Three-Ten All Round	0.92	0.90	0.46	0.53	**2.81**	*2.47*	6.10	4.60	1.30	**12.00**	*11.*	**10.70**	*10.*	...	..
D 7	Two-Ten Corn	0.68	0.41	0.38	0.35	**1.82**	*1.65*	6.34	3.84	1.46	**11.64**	*11.*	**10.18**	*10.*	...	..
J 7	Two-Ten Farm and Garden	0.18	0.35	0.90	0.46	**1.89**	*1.65*	5.66	4.58	2.16	**12.40**	*11.*	**10.24**	*10.*	...	..
D 8	Two-Ten Potato	0.66	0.53	0.21	0.39	**1.79**	*1.65*	6.32	4.00	1.18	**11.50**	*11.*	**10.32**	*10.*	...	..
	Burlington Rendering Co.															
D 10	Animal Fertilizer	0.46	0.42	0.49	1.16	**2.53**	*2.46*	8.08	2.40	0.86	**11.34**	*11.*	**10.48**	*10.*	...	..
B 8	Grain Fertilizer	0.56	0.07	0.60	0.98	**2.21**	*1.23*	7.18	3.55	0.75	**11.48**	*11.*	**10.73**	*10.*	...	..
K 8	Grass Fertilizer	0.73	0.95	1.41	2.24	**5.33**	*4.92*	6.04	2.71	1.89	**10.64**	*9.*	**8.75**	*8.*	...	..
B 9	Potato Fertilizer	0.28	0.98	0.88	1.40	**3.54**	*3.28*	7.42	2.72	3.00	**13.14**	*11.*	**10.14**	*10.*	...	..
D 9	Special Fertilizer	0.65	0.79	0.98	1.72	**4.14**	*4.1*	5.00	4.16	2.04	**11.20**	*9.*	**9.16**	*8.*	...	..
K 1	Vegetable Fertilizer	0.49	0.53	1.58	2.14	**4.74**	*4.1*	6.44	4.53	3.03	**14.00**	*11.*	**10.97**	*10.*	...	..
	The Coe-Mortimer Co.															
D 12	Columbian Corn and Potato Fert., 1916..	0.44	0.37	0.24	0.46	**1.51**	*1.23*	3.60	6.58	1.30	**11.48**	*11.*	**10.18**	*10.*	**0.85**	*1.*
D 14	Gold Brand Excelsior Guano, 1916.....	0.85	0.83	0.50	0.63	**2.81**	*2.47*	4.96	4.22	2.10	**11.28**	*10.*	**9.18**	*9.*	†**1.17**	*1.*
D 15	High Grade Ammo. Superphosphate, 1916	1.03	0.90	0.32	0.63	**2.88**	*2.47*	5.40	4.60	1.46	**11.46**	*11.*	**10.00**	*10.*	...	..
D 13	New Englander Special, 1916	...	0.21	0.45	0.32	**0.98**	*0.82*	4.96	5.09	1.65	**11.70**	*9.*	**10.05**	*8.*	†**0.88**	*1.*
A 7	Original Ammo. Dissolved Phosphate, 1916	0.70	0.56	0.21	0.42	**1.89**	*1.65*	5.32	4.74	1.12	**11.18**	*11.*	**10.06**	*10.*	...	..

†Half or more as sulphate.

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	The Coe-Mortimer Co.—Cont.															
J 5	Prolific Crop Producer, 1916	1.16	1.05	0.63	0.67	**3.51**	*3.29*	5.44	4.68	1.46	**11.58**	*11.*	**10.12**	*10.*	...	..
D 11	Standard Potato Fertilizer, 1916	1.08	1.02	0.36	0.84	**3.30**	*3.29*	4.72	4.56	1.44	**10.72**	*10.*	**9.28**	9.	**1.03**	*1.*
A 6	Top Dressing Manure, 1916	3.84	1.81	0.70	0.60	**6.95**	*6.56*	5.04	3.32	0.92	**9.28**	*9.*	**8.86**	*8.*	...	..
D 16	XXV Ammoniated Phosphate, 1916	0.38	0.32	0.14	0.28	**1.12**	*0.82*	5.74	4.74	0.60	**11.08**	*11.*	**10.48**	*10.*	...	..
	Essex Fertilizer Co.															
B 10	Grain, Grass and Potato Fertilizer	...	0.07	0.52	0.46	**1.05**	*0.82*	8.68	3.33	1.39	**13.40**	*13.*	**12.01**	*12.*	...	...
B 11	Market Garden and Potato Manure	0.38	0.81	0.71	0.84	**2.74**	*2.87*	6.28	3.53	1.23	**11.04**	*11.*	**9.81**	*10.*	...	..
B 12	Potato, Corn and Vegetable	...	1.72	1.30	1.33	**4.35**	*4.1*	6.64	3.39	1.57	**11.60**	*11.*	**10.03**	*10.*	...	..
B 13	XXX Fish Fertilizer	...	0.42	1.02	0.77	**2.21**	*2.46*	6.24	4.02	1.60	**11.86**	*11.*	**10.26**	*10.*	...	..
	International Agricultural Corporation, Buffalo Fertilizer Works															
J 1	Buffalo Ammoniated Phosphate	0.82	0.30	0.78	0.70	**2.60**	*1.2*	3.84	7.48	2.36	**13.68**	*13.*	**11.32**	*12.*	...	..
H 16	Buffalo Economy	0.73	0.18	0.23	0.84	**2.03**	*1.64*	5.28	6.00	1.86	**13.14**	*11.*	**11.28**	*10.*	**1.30**	*1.*
F 2	Buffalo Farmers' Choice	0.29	0.06	0.35	0.70	**1.40**	*0.82*	6.32	4.82	2.10	**13.24**	*11.*	**11.14**	*10.*	...	..
H 15	Buffalo General Favorite	...	0.39	0.13	0.46	**0.98**	*0.82*	5.52	4.06	0.88	**10.46**	*9.*	**9.58**	*8.*	**0.85**	*1.*
F 5	Buffalo High Grade Manure	1.38	0.37	0.14	0.53	**2.42**	*3.29*	4.16	3.68	0.90	**8.74**	*9.*	**7.84**	*8.*	**1.79**	*1.*
F 3	Buffalo New England Special	0.67	0.07	0.59	0.63	**1.96**	*1.65*	3.60	6.51	1.99	**12.10**	*11.*	**10.11**	*10.*	...	..
L 8	Buffalo Potato and Corn	0.31	0.39	0.46	0.70	**1.86**	*1.7*	4.32	5.22	1.66	**11.20**	*9.*	**9.54**	*8.*	**3.45**	*4.*
A 8	Buffalo Potash Special	...	0.46	0.59	0.77	**1.82**	*0.82*	3.76	4.25	1.82	**9.83**	*9.*	**8.01**	*8.*	**3.45**	*3.*
H 14	Buffalo Potato and Truck Manure	0.81	0.14	0.49	0.63	**2.07**	*3.3*	6.64	5.75	1.81	**14.20**	*8.*	**12.39**	*8.*	**1.79**	*4.*
F 1	Buffalo Standard	1.26	0.14	0.50	0.84	**2.74**	*3.29*	3.92	6.10	1.92	**11.94**	*11.*	**10.02**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	International Agricultural Corporation, Buffalo Fertilizer Works—Cont.															
L 11	Buffalo Superior Fertilizer	0.31	0.11	0.69	0.39	**1.50**	*2.5*	3.56	5.30	2.07	**10.93**	*9.*	8.86	*8.*	**1.75**	*3.*
J 2	Buffalo Tip Top	0.60	0.07	0.62	0.53	**1.82**	*0.82*	2.04	6.46	2.02	**10.52**	*9.*	8.50	*8.*	**3.53**	*2.*
A 9	Buffalo Top Dresser	2.54	0.79	0.92	0.70	**4.95**	*5.74*	1.40	5.60	2.46	**9.46**	*7.*	7.00	*6.*	...	..
F 6	Buffalo Triumph	...	0.44	0.68	0.70	**1.82**	*1.65*	3.40	5.53	1.31	**10.24**	*9.*	8.98	*8.*	**3.26**	*2.*
F 4	Buffalo Vegetable and Potato	1.01	0.18	0.60	0.77	**2.56**	*2.47*	2.64	7.43	2.00	**12.07**	*11.*	10.07	*10.*	...	..
	Listers' Agricultural Chemical Works															
A 12	Crescent Ammoniated Superphosphate...	...	0.42	0.39	0.84	**1.65**	*1.65*	5.96	4.17	1.90	**12.03**	*11.*	10.13	*10.*	...	..
A 10	Excelsior Guano	1.02	0.21	0.63	0.88	**2.74**	*2.47*	5.48	4.27	2.69	**12.44**	*11.*	9.75	*10.*	...	..
J 3	Grain and Grass Fertilizer	...	0.13	0.36	0.67	**1.16**	*0.82*	6.88	3.75	1.37	**12.00**	*11.*	10.63	*10.*	...	..
G 14	Potato Manure, 1916	1.85	1.34	0.67	0.77	**4.63**	*4.11*	4.02	4.12	1.86	**10.00**	*9.*	8.14	*8.*	**0.97**	*1.*
G 15	Revised Vermont Corn and Potato Fert..	0.36	0.27	0.21	0.70	**1.54**	*0.82*	6.28	2.82	1.70	**10.80**	*9.*	9.10	*8.*	***1.12**	*1.*
J 4	Special Potato Fertilizer with Potash...	0.96	0.16	0.53	0.74	**2.39**	*2.06*	1.64	6.55	2.37	**10.56**	*9.*	8.19	*8.*	**0.97**	*1.*
G 16	Success Fertilizer, 1916	0.19	0.20	0.49	0.63	**1.51**	*1.23*	6.84	3.21	1.95	**12.00**	*11.*	10.05	*10.*	**1.26**	*1.*
A 11	Superior Ammoniated Superphosphate..	0.96	0.86	0.81	0.98	**3.61**	*3.29*	6.02	4.08	2.00	**12.10**	*11.*	10.10	*10.*	...	..
	Lowell Fertilizer Co.															
G 7	Animal Brand for All Crops	0.39	0.91	0.84	0.91	**3.05**	*2.87*	7.12	3.25	1.63	**12.00**	*11.*	10.37	*10.*	...	..
G 11	Bone Fert. for Corn, Grain, Grass & Veg.	...	0.32	0.94	0.74	**2.00**	*2.05*	6.00	3.44	1.20	**10.64**	*11.*	9.44	*10.*	...	..
G 10	Empress Brand for Corn, Pot. & Grain..	...	0.11	0.55	0.67	**1.33**	*1.23*	5.84	4.19	2.07	**12.10**	*11.*	10.03	*10.*	...	..
G 12	Potato Manure	0.40	0.37	0.78	0.84	**2.39**	*2.46*	6.36	3.66	1.24	**11.26**	*11.*	10.02	*10.*	...	..
G 9	Potato, Corn and Vegetable	0.78	1.39	0.81	1.19	**4.17**	*4.1*	5.78	2.92	2.62	**11.32**	*11.*	8.70	*10.*	...	..

*Mostly as sulphate.

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Lowell Fertilizer Co.—Cont.															
G 8	Potato Phosphate	0.38	1.58	0.56	0.95	**3.47**	*3.28*	7.88	2.42	1.26	**11.56**	*11.*	**10.30**	*10.*	...	..
G 13	Sterling Phosphate	...	0.07	0.53	0.42	**1.02**	*0.82*	8.20	3.37	1.44	**13.01**	*13.*	**11.57**	*12.*	...	..
	National Fertilizer Co.															
K 9	Eureka Potato Fertilizer, 1916	1.12	1.16	0.42	0.77	**3.47**	*2.47*	4.50	5.36	1.48	**11.34**	*10.*	**9.86**	*9.*	**1.13**	*1.*
K 11	Nitrogen Phosphate Mixture No. 3	0.98	0.81	0.28	0.56	**2.63**	*2.47*	5.76	4.60	1.18	**11.54**	*11.*	**10.36**	*10.*	...	..
K 12	Nitrogen Phosphate Mixture No. 4	1.27	1.05	0.45	0.67	**3.44**	*3.29*	6.28	3.87	1.85	**12.00**	*11.*	**10.15**	*10.*	...	..
L 6	Potato Phosphate, 1916	0.73	0.60	0.39	0.70	**2.42**	*2.06*	4.24	5.78	1.23	**11.25**	*9.*	**10.02**	*8.*	**0.98**	*1.*
K 10	Universal Grain and Potato Fertilizer	...	0.20	0.57	0.35	**1.12**	*0.82*	4.60	5.53	1.27	**11.40**	*9.*	**10.13**	*8.*	†**0.69**	*1.*
	New England Fertilizer Co.															
F 11	Corn and Grain Fertilizer	...	0.13	0.99	0.42	**1.54**	*1.23*	5.84	4.10	1.64	**11.58**	*11.*	**9.94**	*10.*	...	..
F 8	Corn Phosphate	...	0.21	0.81	0.77	**1.79**	*2.06*	6.06	3.72	1.18	**10.96**	*11.*	**9.78**	*10.*	...	..
F 9	Potato Fertilizer	...	0.44	0.90	1.12	**2.46**	*2.46*	6.48	3.24	2.50	**12.22**	*11.*	**9.72**	*10.*	...	..
F 7	Potato, Corn and Vegetable	0.73	1.55	0.53	1.40	**4.21**	*4.1*	7.28	2.74	1.80	**11.82**	*11.*	**10.02**	*10.*	...	..
F 10	Superphosphate for All Crops	...	0.91	1.09	0.88	**2.88**	*2.87*	6.16	4.08	1.04	**11.28**	*11.*	**10.24**	*10.*	...	..
	Parmenter & Polsey Fertilizer Co.															
E 16	Corn and Grain Fertilizer	...	0.07	0.52	0.46	**1.05**	*0.82*	8.96	3.41	1.40	**13.77**	*13.*	**12.37**	*12.*	...	..
H 13	Plymouth Rock Brand Fert. for All Crops	0.49	0.98	0.74	1.02	**3.23**	*2.87*	7.22	3.30	1.70	**12.22**	*11.*	**10.52**	*10.*	...	..
L 9	Potato Fertilizer	...	0.34	1.21	0.84	**2.39**	*2.05*	6.06	3.94	1.12	**11.12**	*11.*	**10.00**	*10.*	...	..
H 12	Potato Phosphate	1.05	0.63	0.57	1.19	**3.44**	*3.28*	6.42	2.75	2.85	**12.02**	*11.*	**9.17**	*10.*	...	..

†Half or more as sulphate.

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Reading Bone Fertilizer Co.															
F 13	All Crop Special	...	0.45	0.60	0.56	**1.61**	*1.64*	5.48	4.33	1.53	**11.34**	*11.*	**9.81**	*10.*	...	..
F 12	Farmers' Tankage and Potash	...	0.48	0.15	0.42	**1.05**	*0.82*	3.68	7.28	2.10	**13.06**	*11.*	**10.96**	*10.*	**0.80**	*1.*
A 13	Never Fail Crop Grower	...	0.18	0.45	0.56	**1.19**	*0.82*	7.00	3.11	2.45	**12.56**	*11.*	**10.11**	*10.*	...	..
F 15	Prize Winner	...	1.51	0.49	0.70	**2.70**	*2.47*	6.88	3.05	1.67	**11.60**	*10.*	**9.93**	*9.*	...	..
F 16	Special Grain and Grass Producer	...	0.11	0.59	0.35	**1.05**	*0.82*	3.50	4.04	1.58	**9.12**	*8.*	**7.54**	*7.*	...	..
F 14	Special Potato and Tobacco Manure	...	0.28	0.38	0.39	**1.05**	*0.82*	7.08	5.67	1.89	**14.64**	*13.*	**12.75**	*12.*	...	..
K 15	Truck, Fruit, Tree, Vine, Potato, etc.	...	2.27	0.60	0.60	**3.47**	*3.29*	6.26	3.30	1.18	**10.74**	*9.*	**9.56**	*8.*	...	..
	Rogers & Hubbard Co.															
G 5	All Soils—All Crops Phosphate	0.63	1.05	0.42	0.74	**2.84**	*3.3*	2.76	4.20	2.80	**9.76**	*8.*	**6.96**	*7.*	...	..
G 6	Complete Phosphate	0.17	0.11	0.28	0.63	**1.19**	*1.*	4.00	3.12	3.12	**10.24**	*9.*	**7.12**	*8.*	...	..
G 3	"Bone Base"; Oats and Topdressing	4.81	0.21	0.69	0.39	**6.10**	*6.*	0.04	6.70	5.84	**12.58**	*12.*	**6.74**	*6.*	...	..
G 4	Potato Phosphate	0.42	0.60	0.49	0.70	**2.21**	*2.*	6.56	6.18	4.34	**17.08**	*14.*	**12.74**	*13.*	...	..
G 2	"Bone Base" Soluble Potato Manure	1.72	1.12	0.67	0.95	**4.46**	*4.25*	0.12	8.65	5.63	**14.40**	*12.*	**8.77**	*10.*	†**0.97**	*1.*
G 1	"Bone Base" Sol. Corn & Gen. Crops Man.	0.56	0.84	0.25	1.05	**2.70**	*2.5*	1.00	9.06	5.70	**15.76**	*12.*	**10.06**	*10.*	...	..
J 9	Randolph Potato Growers' Special	0.48	1.20	0.32	0.74	**2.74**	*2.63*	4.56	4.49	3.00	**12.05**	*12.*	**9.05**	*10.*	...	..
	F. S. Royster Guano Co.															
H 7	Cuckoo Crop Grower	0.17	0.11	0.14	0.77	**1.19**	*0.82*	3.86	4.50	1.50	**9.86**	*8.5*	**8.36**	*8.*	***0.84**	*1.*
B 16	Curfew Ammoniated Superphosphate	.....	1.53	0.65	1.19	**3.37**	*3.29*	5.88	2.15	1.23	**9.26**	*8.5*	**8.03**	*8.*	...	..
H 6	Dreadnaught Fertilizer	0.15	0.62	0.42	0.77	**1.96**	*1.65*	5.16	3.48	0.98	**9.62**	*8.5*	**8.64**	*8.*	***1.81**	*2.*
J 14	Innovation Ammoniated Superphosphate.	...	1.32	0.12	1.23	**2.67**	*2.47*	5.28	2.77	0.59	**8.64**	*8.5*	**8.05**	*8.*	...	..

*Mostly as sulphate. †Half or more as sulphate.

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	F. S. Royster Guano Co.—Cont.															
K 7	Logical Compound	...	0.48	0.50	0.77	**1.75**	*1.65*	5.44	3.22	0.88	**9.54**	*8.5*	**8.66**	*8.*	**0.86**	*1.*
E 14	Penguin Ammoniated Superphosphate	0.09	0.44	0.63	0.84	**2.00**	*1.65*	7.32	2.90	1.06	**11.28**	*10.5*	**10.22**	*10.*	...	..
H 5	Utopia Compound	0.22	1.18	0.74	1.30	**3.44**	*2.47*	4.40	3.92	1.54	**9.86**	*8.5*	**8.32**	*8.*	***3.36**	*3.*
	J. W. Sanborn															
H 11	Prof. Sanborn's Chem. Fert., Gr. & Grain	3.32	1.42	0.56	0.56	**5.86**	*4.94*	4.72	3.68	1.00	**9.40**	*9.*	**8.40**	*8.*	...	..
H 9	Prof. Sanborn's Chem. Fert., Hill & Drill.	0.86	0.72	0.39	0.63	**2.60**	*2.47*	4.40	5.48	2.12	**12.00**	*11.*	**9.88**	*10.*	...	..
H 10	Prof. Sanborn's Chem. Fert., Pot. & Corn	1.28	1.04	0.55	0.60	**3.47**	*3.29*	6.34	3.61	1.97	**11.92**	*11.*	**9.95**	*10.*	...	..
	Sanderson Fertilizer & Chemical Co.															
H 8	Atlantic Coast, Bone, Fish & Potash, 1916	0.25	0.14	0.28	1.40	**2.07**	*1.65*	4.66	5.30	1.18	**11.14**	*11.*	**9.96**	*9.*	**1.14**	*1.*
B 14	Corn Superphosphate, 1916	...	0.14	0.91	0.74	**1.79**	*1.65*	7.14	4.11	0.81	**12.06**	*11.*	**11.25**	*10.*	**1.08**	*1.*
B 15	Potato Manure, 1916	...	0.14	0.38	1.44	**1.96**	*2.06*	2.12	6.42	0.88	**9.42**	*9.*	**8.54**	*8.*	**‡1.40**	*1.*
	Virginia-Carolina Chemical Co.															
A 15	Ammoniated Bone Phosphate for all Crops	...	0.32	0.52	1.05	**1.89**	*1.65*	6.98	4.02	3.90	**14.90**	*11.*	**11.00**	*10.*	...	..
A 16	Beef, Blood & Bone BBB with 3% Potash	...	1.51	0.77	1.09	**3.37**	*3.29*	4.56	3.46	3.38	**11.40**	*9.*	**8.02**	*8.*	**‡2.66**	*3.*
K 16	Beef, Blood & Bone BBB without Potash.	0.73	1.02	.074	0.98	**3.47**	*3.29*	4.32	6.12	1.50	**11.94**	*11.*	**10.44**	*10.*	...	..
L 1	20th Century Potato Manure with 2% Pot.	0.59	1.97	0.60	0.98	**4.14**	*4.12*	6.56	2.97	1.39	**10.92**	*9.*	**9.53**	*8.*	**‡2.11**	*2.*
L 2	20th Century Potato Manure without Pot.	...	2.14	0.67	1.93	**4.74**	*4.12*	8.66	2.52	1.22	**12.40**	*11.*	**11.18**	*10.*	...	..
A 14	XXXX Fish and Potash Mixture	...	0.35	0.67	0.98	**2.00**	*1.65*	4.04	4.40	2.92	**11.36**	*9.*	**8.44**	*8.*	***1.12**	*1.*

*Mostly as sulphate. ‡From a fourth to a third (approximately) as sulphate.

CONCERNING THE ANALYSES OF CERTAIN BRANDS

Armour Fertilizer Works. E 2. Four-Eight-Zero. A resample at the same point afforded figures quite unlike those shown in the table. The nitrogen content was 3.40 instead of 3 percent, being above guaranty in this respect. The available phosphoric acid content was 7.21 instead of 7.76 percent, being decidedly below guaranty in this respect. Furthermore the resample was nitrated, whereas the initial sample contained only a trace of nitrate.

Bowker Fertilizer Co. D 5. Superphosphate with Ammonia two percent. A second sample taken at another location met its guaranty.

Essex Fertilizer Co. B 11. Market Garden and Potato Manure. A second sample taken at another location met its guaranty.

B 13. XXX Fish Fertilizer. A second sample taken at another location met its nitrogen guaranty but failed by almost a half percent to meet its available phosphoric acid guaranty. However, the excess of nitrogen more than made good, speaking commercially, for the shortage in available phosphoric acid.

International Agricultural Corporation, Buffalo Fertilizer Co.

J 1. Ammoniated Phosphate. A second sample taken at another location resembled the one shown in the table, being similarly high in nitrogen and lacking in available phosphoric acid.

F 5. High Grade Manure. H 14. Potato and Truck. Analyses of resamples taken at the same point confirmed the figures shown in the table.

F 1. Standard Fertilizer. A second sample taken at another location met its guaranty.

A 9. Topdresser. A second sample taken at another location failed. but less decidedly to meet its nitrogen guaranty.

No new samples or resamples could be taken of L 8. Potato and Corn and L 11. Superior Fertilizer.

Listers' Agricultural Chemical Works. A 10. Excelsior Guano. A second sample taken at another location was somewhat more lacking in available phosphoric acid than the one shown in the table.

Lowell Fertilizer Co. G 11. Bone Fertilizer for Corn, Grain, Grass and Vegetables. A second sample taken at another location met its guaranty.

G 9. Potato, Corn and Vegetable. A second sample taken at another location met its guaranty.

G 13. Sterling Phosphate. A second sample taken at another location met its guaranty.

New England Fertilizer Co. F 8. Corn Phosphate. A second sample taken at another location met its nitrogen but not its available phosphoric acid guaranty, the shortage in the latter case being slight.

F 9. Potato Fertilizer. A second sample taken at another location was somewhat more lacking in available phosphoric acid than the one shown in the table.

Parmenter & Polsey Co. H 12. Potato Phosphate. A second sample taken at another location met its guaranty.

Rogers & Hubbard Co. G 5. All Soils—All Crops Phosphate. The analysis of second sample taken at another location reversed the result secured with the sample reported in the table. The available phosphoric acid of the second sample was below guaranty, whereas its nitrogen content met the guaranty.

G 6. Complete Phosphate. A second sample taken at another location afforded results which were practically identical with those secured in the first instance.

G 4. Potato Phosphate. A second sample taken at another location was somewhat more lacking in available phosphoric acid than the one shown in the table.

CONCERNING THE TABLES ON PAGES 47 TO 52

There have been those who have found that the tables of analyses printed in the annual bulletin were somewhat complicated and difficult to understand, that comparisons were not readily made, and they have pled for simpler, more direct statements. The writers have felt that full statements as to the analytical data were really needed—and they still feel so. They have felt that the ideas could be readily grasped if one set himself seriously to study the matter. However, recognizing that publicity is the most effective weapon in their hands in the enforcement of the law and that anything which will tend to clarify the situation in the buyer's mind is worth while, last year for the first time they formulated an additional and simpler statement as to the results of inspection. This is set forth on pages 47 to 52.

In order to set forth the meaning of these new tables a few words of explanation seem necessary.

The law requires a manufacturer to state on each package how much plant food he is selling. Long years of experience have indicated clearly that manufacturers rarely give more than they promise; on the average of late years it is not more than five percent. Such being the case, the buyer is interested primarily in knowing whether or not the promise which has been made has been kept.

The first three figures in the table, reading horizontally following the brand name, indicate what the promise is; and the word following, usually "Yes," rarely "No," tells in this laconic, straightforward in available form.

The remaining words and figures, other than the last figure in the horizontal line, have to do with *the quality of the nitrogen* which is furnished. This is an important item of information. In the first place *by the use of the words "Passed" or "Inferior" the character of the organic nitrogen used is indicated.* The former word is used whenever the analysis indicated a good or passable grade; the latter when it did not. The next three horizontal statements in terms of figures indicate *the proportions of the total nitrogen present in the several forms;* of nitrate nitrogen—derived from nitrate of soda; of ammonia—derived usually from sulphate of ammonia; and of organic nitrogen—derived usually from materials like tankage, dried blood, dried fish and other residues of a nitrogenous character. These figures are expressed in terms of tenths, and the three added always equal unity. Thus if, for example, a set of figures reads horizontally .4 .3 .3, it means that the nitrogen was furnished in those proportions in the form of nitrate, in the form of ammonia salts and in the form of organic nitrogen; 4 parts in 10 as nitrate, 3 parts in 10 as ammonia salts, and 3 parts in 10 as organic matter. If, as is often the case, no figure whatever appears, it should be understood that no nitrogen in the form indicated by the blank was used in the goods. This seems a simple, straightforward statement. It does not indicate whether the promise was high or low; that is betrayed by the manufacturer's guaranty, the first figures in the horizontal column. It simply shows what sort of material the manufacturer has used to furnish the nitrogen.

The last figure, reading horizontally, indicates in terms of a decimal fraction, *what proportion of the total phosphoric acid is furnished fashion whether or not the promise has been kept.*

So far as potash is concerned the manufacturer's guaranty column serves the purpose for this year.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	American Agricultural Chemical Company, 92 State St., Boston, Mass.									
J 12	AA Potato Grower, 1916.....	3.7	8	1	Yes	Passed	.3	.3	.4	.9
C 1	Ammoniated Fertilizer A.....	0.82	10	..	"	"	.4	.2	.4	.9
C 2	Ammoniated Fertilizer AA...	1.65	10	..	"	"	.1	.2	.7	.9
C 3	Ammoniated Fertilizer AAA..	2.47	10	..	"	"	.3	.3	.4	.9
C 4	Ammoniated Fertilizer AAAA.	3.29	10	..	"	"	.3	.4	.3	.8
C 6	Cereal and Root Fertilizer....	2.47	10	..	"	"	.3	.3	.4	9
K 2	Extra Quality Potato Manure.	4.11	10	..	"	"	.4	.3	.3	.9
E 6	General Crop Grower, 1916...	1.65	9	1	"	"	.3	.2	.5	.9
C 7	Grain and Seeding Fertilizer.	1.65	10	..	"	"	.4	.2	.4	.9
J 11	Grass and Lawn Topdressing.	3.7	8	1	"	"	.3	.3	.4	.9
H 1	High Grade Fertilizer, 1916..	2.47	9	1	"	"	.3	.3	.4	.8
C 5	High Grade Grass Topdressing, without Potash	6.58	8	..	"	"	.5	.3	.2	.9
L 10	Odorless Grass and Lawn Topdressing, without Potash...	4.11	10	..	"	"	.1	.3	.6	.9
E 5	Special Vegetable Fertilizer..	3.29	10	..	"	"	.3	.4	.3	.8
	(Bradley Fertilizer Co. Brands)									
J 8	Complete Manure for Potatoes and Vegetables, 1916	3.29	9	1	Yes	Passed	.3	.3	.4	.9
B 5	Corn Phosphate, 1916.....	1.65	10	1	"	"	.2	.2	.6	.9
A 2	Eclipse Phosphate, 1916.....	1.23	10	1	"	"	.3	.2	.5	.9
A 3	General Fertilizer	1.65	10	..	"	"	.4	.3	.3	.9
C 9	Grain Fertilizer	0.82	10	..	"	"	.4	.3	.3	.9
C 8	Maine Potato Special	4.11	10	..	"	"	.4	.3	.3	.9
A 1	Potato Fertilizer, 1916.....	2.06	8	1	"	"	.2	.3	.5	.8
C 11	Potato Manure, 1916.....	2.47	9	1	"	"	.3	.3	.4	.9
B 7	Root Crop Manure.....	3.29	10	..	"	"	.1	.5	.4	..
A 4	Special Corn Phosphate without Potash	1.65	10	..	"	"	.4	.3	.3	.9
C 10	Special Potato Fertilizer without Potash	1.65	10	..	"	"	.3	.3	.4	.9
C 12	Special Potato Manure without Potash	2.47	10	..	Yes	Passed	.4	.3	.3	.8
B 6	Special XL Superphosphate without Potash	2.47	10	..	"	"	.3	.3	.4	.9
J 10	Three Star Special with Potash	2.47	8	3	"	"	.3	.3	.4	.9
B 4	Universal Crop Phosphate....	2.47	10	..	"	"	.3	.3	.4	.9
A 5	XL Superphos. of Lime, 1916.	2.47	9	1	"	"	.1	.3	.6	.9
	(Crocker Fertilizer & Chemical Co. Brands)									
E 8	Ammo. Corn Phosphate, 1916.	2.06	8	1	Yes	Passed	.3	.3	.4	.8
E 10	New Rival Ammoniated Superphosphate, 1916	0.82	10	1	"	"	.2	.1	.7	.9
E 9	Potato, Hop and Tobacco Fertilizer, 1916	2.06	10	1	"	"	.3	.2	.5	.9
	(Darling Fertilizer Co. Brands)									
E 11	General Fertilizer, 1916	0.82	8	1	Yes	Passed	..	.1	.9	.9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
	Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
American Agricultural Chemical Company—Continued									
(Great Eastern Fertilizer Co. Brands)									
C 13 General, 1916	0.82	8	1	Yes	Passed	.3	.3	.4	.8
E 13 Northern Corn Special, 1916.	2.06	8	1	"	"	.3	.3	.4	.8
E 12 Potato Manure, 1916	2.06	10	1	"	"	.3	.3	.4	.9
(Pacific Guano Co. Brands)									
K 14 Nobsque Guano, 1916	0.82	8	1	Yes	Passed	.2	.2	.6	.9
C 14 Special Potato Fertilizer without Potash	1.65	10	..	"	"	.4	.2	.4	.8
J 16 Soluble Pacific Guano, 1916	1.65	10	1	"	"	.3	.3	.4	.9
K 13 Special Soluble Pacific Guano without Potash	1.65	10	..	"	"	.4	.2	.4	.9
(Quinnipiac Co. Brands)									
E 15 Spec. Corn Man. without Pot.	1.65	10	..	Yes	Passed	.3	.3	.4	.9
C 15 Spec. Potato Phos. without Pot.	1.65	10	..	"	"	.3	.2	.5	.8
(Read Fertilizer Co. Brands)									
J 13 Farmers' Friend Superph., 1916	2.06	8	1	Yes	Passed	.3	.3	.4	.8
D 1 Practical Fertilizer, 1916	0.82	8	1	"	"	..	.3	.7	.9
(Williams & Clark Fertilizer Co. Brands)									
H 4 Americus Corn Phos., 1916	1.65	10	1	Yes	Passed	.3	.3	.4	.9
L 4 Americus Potato Manure, 1916	2.06	8	1	"	"	.3	.3	.4	9
L 3 Special Americus Corn Phosphate without Potash	1.65	10	..	"	"	.3	.3	.4	.8
C 16 Special Americus Potato Manure without Potash	1.65	10	..	"	"	.4	.3	.3	.9
Armour Fertilizer Works, 930-938 Equitable Bldg., Baltimore, Md.									
L 7 Five-Eight-Four	4.11	8	4	Yes	Passed	.2	.1	.7	.8
E 2 Four-Eight-Zero	3.29	8	..	No	"	..	.4	.6	.9
D 4 Grain Grower	1.65	8	2	Yes	Not passed	.3	.2	.5	.9
D 2 One-Eight-Two	0.82	8	2	"	"	..	.2	.8	.9
L 12 Two-Eight-One	1.65	8	1	"	Passed	.2	.1	.7	.9
E 3 Two-Eight-Three	1.65	8	3	"	"	.2	.1	.7	.8
E 1 Two-Eleven-Zero	1.65	11	..	"	"	..	.3	.7	.8
D 3 Wheat, Corn and Oats Special	0.82	7	1	"	"	..	.1	.9	.9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.									
K 5	Brighton Phosphate	0.82	8	1	Yes	Passed	..	.3	.7	.9
B 3	Corn Phosphate, 1916	1.65	10	1	"	"	.3	.3	.4	.9
K 3	Five-Eight General Crop	4.11	8	..	"	"	.2	.3	.5	.8
E 7	Five-Ten Early Crop	4.11	10	..	"	"	.4	.4	.2	.9
J 15	Four-Ten Hill and Drill	3.29	10	..	"	"	.3	.3	.4	.8
H 2	High Nitrogen Mixture, 1916, without Potash	8.23	5	..	"	"	.4	.4	.2	.8
D 6	One-Ten Sure Crop	0.82	10	..	"	"	.4	.2	.4	.9
B 2	Potato Phosphate, 1916	1.65	10	1	"	"	.3	.3	.4	.9
B 1	Stockbridge Cereal Manure without Potash, 1916	3.29	10	..	"	"	.3	.3	.4	.8
L 5	Stockbridge General Crop Manure, 1916	3.29	9	1	"	"	.3	.3	.4	.9
K 6	Superphos. with Ammonia, 1%	0.82	10	..	"	"	.4	.2	.4	.9
D 5	Superphos. with Ammonia, 2%	1.65	10	..	"	"	..	.3	.7	.8
K 4	Superphos. with Ammonia, 3%	2.47	10	..	"	"	.4	.2	.4	.9
J 6	Sure Crop Phosphate, 1916	0.82	10	1	"	"	..	.2	.8	.9
H 3	Three-Ten All Round	2.47	10	..	Yes	Passed	.3	.3	.4	.9
D 7	Two-Ten Corn	1.65	10	..	"	"	.4	.2	.4	.9
J 7	Two-Ten Farm and Garden	1.65	10	..	"	"	.1	.2	.7	.8
D 8	Two-Ten Potato	1.65	10	..	"	"	.4	.3	.3	.9
	Burlington Rendering Co., North Ave., Burlington, Vt.									
D 10	Animal Fertilizer; 3/10	2.46	10	..	Yes	Passed	.2	.2	.6	.9
B 8	Grain Fertilizer; 1.5/2/10	1.23	10	..	"	"	.3	..	.7	.9
K 8	Grass Fertilizer; 6/8	4.92	8	..	"	"	.1	.2	.7	.8
B 9	Potato Fertilizer; 4/10	3.28	10	..	"	"	.1	.3	.6	.8
D 9	Special Fertilizer; 5/8	4.1	8	..	"	"	.2	.2	.6	.8
K 1	Vegetable Fertilizer; 5/10	4.1	10	..	"	"	.1	.1	.8	.8
	The Coe-Mortimer Co., 51 Chambers St., New York, N. Y.									
D 12	Columbian Corn and Potato Fertilizer, 1916	1.23	10	1	Yes	Passed	.3	.2	.5	.9
D 14	Gold Br. Excel. Guano, 1916	2.47	9	1	"	"	.3	.3	.4	.8
D 15	High Grade Ammoniated Superphosphate, 1916	2.47	10	..	"	"	.4	.3	.3	.9
D 13	New Englander Special, 1916.	0.82	8	1	"	"	..	.2	.8	.9
A 7	Original Ammoniated Dissolved Phosphate, 1916	1.65	10	..	"	"	.4	.3	.3	.9
J 5	Prolific Crop Producer, 1916	3.29	10	..	"	"	.3	.3	.4	.9
D 11	Standard Potato Fert., 1916	3.29	9	1	"	"	.3	.3	.4	.9
A 6	Top Dressing Manure, 1916	6.56	8	..	"	"	.5	.3	.2	.9
D 16	XXV Ammo. Phosphate, 1916	0.82	10	..	"	"	.3	.3	.4	.9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Essex Fertilizer Co., 89 North Market St., Boston, Mass.									
B 10	Grain, Grass and Potato Fert..	0.82	12 ..		Yes	Passed	..	.1	.9	.. .9
B 11	Market Garden and Potato...	2.87	10 ..		No	"	.1	.3	.6	.. .9
B 12	Potato, Corn and Vegetable..	4.1	10 ..		Yes	Passed	..	.4	.6	.. .9
B 13	XXX Fish Fertilizer	2.46	10 ..		"	"	..	.2	.8	.. .9
	International Agricultural Corporation, Buffalo Fertilizer Works, 812 Marine Bank Bldg., Buffalo, N. Y.									
J 1	Buffalo Ammoniated Phosphate	1.2	12 ..		Yes	Passed	.3	.1	.6	.. .8
H 16	Buffalo Economy	1.64	10	1	"	"	.4	.1	.5	.. .9
F 2	Buffalo Farmers' Choice	.0.82	10 ..		"	"	.2	..	.8	.. .8
H 15	Buffalo General Favorite	0.82	8	1	"	"	..	.4	.6	.. .9
F 5	Buffalo High Grade Manure..	3.29	8	1	No	"	.5	.2	.3	.. .9
F 3	Buffalo New Englander Special	1.65	10 ..		Yes	"	.3	..	.7	.. .8
L 8	Buffalo Potato and Corn	1.7	8	4	"	"	.2	.2	.6	.. .8
A 8	Buffalo Potash Special	0.82	8	3	"	"	..	.2	.8	.. .8
H 14	Buffalo Potato and Truck....	3.3	8	4	No	"	.4	.1	.5	.. .9
F 1	Buffalo Standard	3.29	10 ..		No	"	.4	..	.6	.. .8
L 11	Buffalo Superior Fertilizer...	2.5	8	3	No	"	.2	.1	.7	.. .8
J 2	Buffalo Tip Top	0.82	8	2	Yes	"	3.	..	.7	.. .8
A 9	Buffalo Topdresser	5.74	6 ..		No	"	.5	.1	.4	.. .9
F 6	Buffalo Triumph	1.65	8	2	Yes	"	..	.2	.8	.. .9
F 4	Buffalo Vegetable and Potato.	2.47	10 ..		"	"	.4	.1	.5	.. .8
	Listers' Agricultural Chemical Works, Lister Ave., Newark, N. J.									
A 12	Crescent Ammo. Superphos...	1.65	10 ..		Yes	Passed	..	.3	.7	.. .8
A 10	Excelsior Guano	2.47	10 ..		"	"	.4	.1	.5	.. .8
J 3	Grain and Grass Fertilizer...	0.82	10 ..		"	"	..	.1	.9	.. .9
G 14	Potato Manure, 1916.....	4.11	8	1	"	"	.4	.3	.3	.. .8
G 15	Revised Vermont Corn and Potato Fertilizer	0.82	8	1	"	"	.2	.2	.6	.. .8
J 4	Special Potato Fertilizer with Potash	2.06	8	1	"	"	.4	.1	.5	.. .8
G 16	Success Fertilizer, 1916;	1.23	10	1	"	"	.1	.1	.8	.. .8
A 11	Superior Ammo. Superphos...	3.29	10 ..		"	"	.3	.2	.5	.. .8
	Lowell Fertilizer Co., 40 North Market St., Boston, Mass.									
G 7	Animal Brand for All Crops..	2.87	10 ..		Yes	Passed	.1	.3	.6	.. .9
G 11	Bone Fertilizer for Corn, Grain, Grass and Vegetables	2.05	10 ..		No	"	..	.2	.8	.. .9
G 10	Empress Brand for Corn, Potatoes and Grain	1.23	10 ..		Yes	Passed	..	.1	.9	.. .8
G 12	Potato Manure	2.46	10 ..		"	"	.2	.2	.6	.. .9
G 9	Potato, Corn and Vegetable..	4.1	10 ..		No	"	.2	.3	.5	.. .8
G 8	Potato Phosphate	3.28	10 ..		Yes	"	.1	.4	.5	.. .9
G 13	Sterling Phosphate	0.82	12 ..		"	"	..	.1	.9	.. .9

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
National Fertilizer Co., 92 State St., Boston, Mass.										
K 9	Eureka Potato Fertilizer, 1916	2.47	9	1	Yes	Passed	.3	.3	.4	.9
K 11	Nitrogen Phosphate Mixture No. 3	2.47	10	..	"	"	.4	.3	.3	.9
K 12	Nitrogen Phosphate Mixture No. 4	3.29	10	..	"	"	.3	.3	.4	.8
L 6	Potato Phosphate, 1916	2.06	8	1	"	"	.3	.2	.5	.9
K 10	Universal Grain and Potato	0.82	8	1	"	"	..	.2	.8	.9
New England Fertilizer Co., 40A North Market St., Boston, Mass.										
F 11	Corn and Grain Fertilizer	1.23	10	..	Yes	Passed	..	.1	.9	.8
F 8	Corn Phosphate	2.06	10	..	No	"	..	.1	.9	.9
F 9	Potato Fertilizer	2.46	10	..	Yes	"	..	.2	.8	.8
F 7	Potato, Corn and Vegetable	4.1	10	..	"	"	.2	.3	.5	.8
F 10	Superphosphate for All Crops.	2.87	10	..	"	"	..	.3	.7	.9
Parmenter & Polsey Fertilizer Co., 41 North Market St., Boston, Mass.										
E 16	Corn and Grain Fertilizer	0.82	12	..	Yes	Passed	..	..	.10	.9
H 13	Plymouth Rock Brand Fert.	2.87	10	..	"	"	.2	.3	.5	.9
L 9	Potato Fertilizer	2.05	10	..	"	"	..	.1	.9	.9
H 12	Potato Phosphate	3.28	10	..	No	"	.3	.2	.5	.8
Reading Bone Fertilizer Co., Reading, Pa.										
F 13	All Crops Special	1.64	10	..	Yes	Passed	..	.3	.7	.9
F 12	Farmers' Tankage and Potash for Corn, Grain and Grass.	0.82	10	1	"	"	..	.5	.5	.8
A 13	Never Fail Crop Grower	0.82	10	..	"	"	..	.2	.8	.8
F 15	Prize Winner	2.47	9	..	"	"	..	.6	.4	.9
F 16	Special Grain and Grass Producer	0.82	7	..	Yes	Passed	..	.1	.9	.8
F 14	Special Potato and Tobacco Manure	0.82	12	..	"	"	..	.3	.7	.9
K 15	Truck, Fruit, Tree, Vine, Potato and Tobacco Grower	3.29	8	..	"	"	..	.2	.8	.9
Rogers & Hubbard Co., Middletown, Conn.										
G 5	All Soils—All Crops Phos.	3.3	7	..	No	Passed	.2	.4	.4	.7
G 3	"Bone Base"; Oats and Top-dressing	6.	6	..	Yes	"	.8	..	.2	.5
G 2	"Bone Base" Soluble Potato Manure	4.25	10	1	No	"	.4	.2	.4	.6
G 1	"Bone Base" Soluble Corn and General Crops Manure	2.5	10	..	Yes	"	.2	.3	.5	.7
G 6	Complete Phosphate	1.	8	..	No	"	.2	.1	.7	.7
G 4	Potato Phosphate	2.	13	..	Yes	"	.2	.3	.5	.7
J 9	Randolph Pot. Growers' Spec.	2.63	10	..	No	"	.2	.4	.4	.7

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total Phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	F. S. Royster Guano Co., 1604-1614 Munsey Bldg., Baltimore, Md.									
H 7	Cuckoo Crop Grower	0.82	8	1	Yes	Not passed	.2	.1	.7	.8
B 16	Curfew Ammo. Superphos.	3.29	8	..	Yes	Passed	..	.4	.6	.9
H 6	Dreadnaught Fertilizer	1.65	8	2	"	"	.1	.3	.6	.9
J 14	Innovation Ammo. Superphos.	2.47	8	..	"	"	..	.5	.5	.9
K 7	Logical Compound	1.65	8	1	"	"	..	.3	.7	.9
E 14	Penguin Ammo. Superphos.	1.65	10	..	"	"	..	.2	.8	.9
H 5	Utopia Compound	2.47	8	3	"	"	.1	.3	.6	.8
	J. W. Sanborn, Pittsfield, N. H.									
H 11	Prof. Sanborn's Chemical Fertilizer for Grass and Grain	4.94	8	..	Yes	Passed	.6	.2	.2	.9
H 9	Prof. Sanborn's Chemical Fertilizer for Hill and Drill	2.47	10	..	"	"	.3	.3	.4	.8
H 10	Prof. Sanborn's Chemical Fertilizer, Potatoes and Corn	3.29	10	..	"	"	.4	.3	.3	.8
	Sanderson Fertilizer and Chemical Co., Box 172, New Haven, Conn.									
H 8	Atlantic Coast, Bone, Fish and Potash, 1916	1.65	9	1	Yes	Passed	.1	.1	.8	.9
B 14	Corn Superphoshate, 1916	1.65	10	1	"	"	..	.1	.9	.9
B 15	Potato Manure, 1916	2.06	8	1	"	Not passed	..	.1	.9	.9
	Virginia-Carolina Chemical Co., 120 Broadway, New York, N. Y.									
A 15	Ammoniated Bone Phosphate for All Crops	1.65	10	..	Yes	Passed	..	.2	.8	.7
A 16	Beef, Blood and Bone BBB with 3 Percent Potash	3.29	8	3	"	"	..	.5	.5	.7
K 16	Beef, Blood and Bone BBB without Potash	3.29	10	..	"	"	.2	.3	.5	.9
L 1	Twentieth Century Potato Manure with 2 Percent Potash	4.12	8	2	"	"	.1	.5	.4	.9
L 2	Twentieth Century Potato Manure without Potash	4.12	10	..	"	"	..	.5	.5	.9
A 14	XXXX Fish and Potash Mix.	1.65	8	1	"	"	..	.2	.8	.8

*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

VI. CONCERNING FARM MANURES

BY R. T. BURDICK,
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INTRODUCTION

Farm manures, their chemical composition and physical characteristics, application and use, were discussed in bulletin 108 issued in 1904. This publication has long been out of print and it seems worth while to submit another article dealing with the same subject.

Estimates made and discussed in No. 108 indicated that 20 cows, 4 horses and 10 pigs would furnish in their excreta plant food which surely would be worth more than $500. And a 20-cow, 4-horse and 10-pig farm is not far from the average in Vermont. Of course much of this never gets to the fields, being lost in the pasture, on the road and elsewhere. Furthermore, estimates based on the census of 1900 indicated that the animals on Vermont farms voided yearly about 80,000,000 pounds of nitrogen, 50,000,000 pounds of potash and 20,000,000 pounds of phosphoric acid. This is more than 50 times as much nitrogen, more than 150 times as much potash and nearly four times as much phosphoric acid as is brought into the State annually in the form of commercial fertilizer. About four-fifths of it is of bovine and about one-seventh is equine origin. If one should attempt to assign a commercial value to this vast mass of plant food—an impossible task save in the most general way for reasons fully set forth on page 58;—if one should disregard all of the many important functions it performs other than the mere matter of plant food purveyal, it would doubtless represent a sum amounting to from 25 to 30 times the amount paid annually in Vermont for commercial fertilizers. Yet how oblivious many of our farmers are concerning its value! How few realize—if we may judge by their actions which are supposed to speak in trumpet tongues as compared with words—the need of conserving it to the utmost! How many Vermont farmers would store their commercial fertilizers under the eaves of the barn; or would spread it in checkerboard piles over a field and let it stand thus for several days? It is almost as sensible a procedure as to throw manure out of the window.

We *hear* farmers say that they engage in stock raising rather than, let us say, in market gardening or grain farming, for the value of the manure which is produced. We *see* farms with the manure piled under the eaves, piled on flooded stream lands and spread haphazard on the fields. While manurial potash is leaching into the subsoil

and by countless thousands of tons draining into the ocean, we grumble at the excessive cost and limited supply of that which we buy.

COMPOSITION

The general terms "manure," "farm manure" and "mixed manures" are used in this article in an inclusive way to cover the mixed solid and liquid excrements of all sorts of farm animals, together with the materials used as litter or bedding. Now mixed manure differs widely in its value, depending upon several different factors, including the kind of animal, the character of its feed, the nature of the litter and the care or lack of care with which it is handled. Van Slyke (14) states that mixed manure may vary as follows:

Nitrogen: From 0.4 to 0.8 percent; average, 0.5 percent.

Phosphoric acid: From 0.2 to 0.4 percent; average, 0.25 percent.

Potash: From 0.4 to 0.8 percent; average, 0.5 percent.

A ton of average manure may be expected to contain 10 pounds of nitrogen, 5 pounds of phosphoric acid and 10 pounds of potash.

The liquid and solid excreta of the several classes of animals differ widely. Such factors as the age of the animal and the feed so affect their composition that analytical results are highly variable. This is particularly true of the feces. Van Slyke (14) indicates the following proportions of the total excrement of the more common farm animals voided as solid and liquid, their average compositions and that of the mixed excrement of each class.

THE COMPOSITION OF FRESH MANURE

	Excrement	Water	Nitrogen	Phosphoric acid	Potash
		%	%	%	%
Horse	Solid, 80 percent.....	75	0.55	0.30	0.40
	Liquid, 20 percent...	90	1.35	Trace	1.25
	Whole manure	78	0.70	0.25	0.55
Cow	Solid, 70 percent.....	85	0.40	0.20	0.10
	Liquid, 30 percent....	92	1.00	Trace	1.35
	Whole manure	87	0.60	0.15	0.45
Pig	Solid, 60 percent.....	80	0.55	0.50	0.40
	Liquid, 40 percent...	97	0.40	0.10	0.45
	Whole manure	87	0.50	0.35	0.40
Sheep	Solid, 67 percent....	60	0.75	0.50	0.45
	Liquid, 33 percent...	85	1.35	0.05	2.10
	Whole manure	68	0.95	0.35	1.00
Hen	Whole manure	55	1.00	0.80	0.40

Horse and sheep manures are frequently called "dry manures." The table shows that the water contents of the entire manure from these animals average 78 and 68 percents respectively. Cattle and swine manures are called "cold" or "wet manures." They contain 87 percent of water. Properly to conserve the manures from all classes of animals it is highly desirable that they be mixed, so that the cooling nature of the moist manures may tend to check the rapidity of the fermentation or "fire-fanging" of the dry manures.

The high nitrogen and potash contents of the several liquid as compared with those in the solid manures should be stressed. Not only are the amounts greater but, being in a soluble form, the plant food is more quickly available than that contained in the feces. Van Slyke (14) shows that somewhat less than half of the nitrogen and nearly two-thirds of the potash voided by the larger farm animals are found in the urine. Swine void one-third, horses three-eighths and cows and sheep half the nitrogen of their excreta by way of the kidneys; swine and horses somewhat less than half, sheep two-thirds and cows seven-eighths of the potash in the liquid. Swine void one-eighth of their phosphoric acid outgo in the urine, while other animals pass little or none save in the feces. In view of the fact that the bulk of the farm manure in Vermont is of bovine origin, the figures 51 and 85 percents for nitrogen and potash voidings respectively are significant.

THE EFFECT OF FOOD

The food affects the composition of manure, for obvious reasons. When such highly nitrogenous concentrates as cottonseed and linseed meals are fed, or when such legumes as alfalfa or clover are furnished, the manure contains more plant food than when cornmeal, oat straw and timothy hay form the bulk of the ration. Indeed, cottonseed meal contains so much plant food that hundreds of thousands of tons are used in commercial fertilizer manufacture, especially in the South, and it has been largely used thus on New England tobacco fields for a generation or more. It costs too much today for Vermont farmers to use it in this way. Furthermore, they—or the better informed of them—realize that if it is fed to their stock they can secure—according to the care or lack of care with which they attempt to preserve manure—from 50 to 75 percent or more of its total fertilizing constituents in the manure after the animal has made use of it as food. While cottonseed meal is the richest of all concentrates in plant food contents, the same argument may be used for many other

proteinous concentrates and roughages which serve the dual purpose of animal food and plant food. They are expensive fertilizers when used directly as such, but often are very well worth feeding in order to secure a double benefit—better stock and richer farm manure.

THE EFFECT OF AGE

The proportion of the total plant food consumed in the ration which is recovered in the farm manure is affected by the age of the animal. A mature animal—for example, a ten-year old work horse—uses its food simply to maintain body weight. If it increases in weight the gain is usually of fat only, and fat contains neither nitrogen, phosphoric acid nor potash. Hence it is that all the plant food a mature animal consumes is excreted in the urine and feces. One may count on getting almost 100 percent. On the other hand, young and growing animals build much of the phosphoric acid and nitrogen into their bones, muscles and other tissues, while milch cows utilize a considerable proportion in milk production. However, it should be said that individual animals vary as to their ability to use food. Some are better able than others to assimilate it. It is safe to assume that from 50 to 75 percent of the plant food which is present in the ration is voided by growing animals and by milch cows, from 85 to 95 percent by fattening animals and from 95 to 100 percent by work animals.

THE EFFECT OF BEDDING

The nature of the bedding or litter affects the agricultural value and composition of farm manure. Bedding is used for several purposes—to increase the bulk of the manure, to augment the bodily comfort of the animals, to absorb and retain the urine, to furnish humus and plant food. It tends to retard over-rapid fermentation and to prevent loss and is itself bettered for manurial purposes by its admixture with the feces and urine. The more common beddings used in Northern New England are the straws, sawdust, shavings and leaves.

Straw makes manure more bulky and contains about as much plant food as does average manure. While this is not as available as is the plant food naturally present in the excreta which has become broken down by the processes of digestion, it soon decomposes in the soil. Sawdust and shavings rot much more slowly and are less bulky than is straw and they contain considerably less plant food. In case straw is abundant it may, all things considered, be preferred to sawdust;

yet on the other hand it cannot be too srongly insisted that sawdust and shavings do not injuriously affect the land. They outclass straw in one important respect, namely, their absorbent powers. One hundred pounds of oat straw absorbs 285 pounds of water whereas 100 pounds of sawdust absorbs 435 pounds (4), being half as good again an absorbent. Nine pounds of straw or six of sawdust or shavings are needed to absorb a cow's 24 hour voidings. However, if enough bedding were used entirely to absorb the urine, the manure would be too dry and bulky. On this account, as well as for the reason that the cattle are out of the barn more or less, from four to five pounds straw and from two to three pounds sawdust or shavings would seem to be a fair daily allowance, varying according to the season. The Ohio station (12) found that seven pounds of straw were needed when steers were kept in a cement floored stall. Few farmers use enough bedding.

If the animals stand on tight concrete floors and a tight storage pit is available, considerable liquid manure can be handled without absorption, and in that condition tends to keep the pit pile moist. It is seldom worth while to store the urine separately in a cistern, for the reason that special apparatus is needed wherewith to spread it and that the solid manure is apt to become too dry and to fire-fang.

AMOUNT PRODUCED

Having briefly outlined the causes for variation in composition of manure, it seems desirable to offer an estimate of the amount produced. Lyon, Fippin and Buckman (8) have compiled the data as determined by several experiment stations and expressed them on the 1,000 pounds live weight basis—a better method of stating values than on the basis of individual animals, in view of their great diversity in size—as follows:

Horse, 50 pounds daily, 9.1 tons annually; cow, 70 pounds daily, 12.7 tons annually; steer, 40 pounds daily, 7.3 tons annually; swine, 85 pounds daily, 15.5 tons annually; sheep, 34 pounds daily, 6.2 tons annually.

Van Slyke (14) estimates that 1,000 pounds live weight of poultry, for example a flock of 200 birds averaging five pounds each, voids 23 pounds daily or 4¼ tons annually.

These variations are due largely to differences in the character of the food eaten and in the water content of the several manures.

MONETARY VALUE

The monetary value of farm manure may be computed after a fashion from its average composition as shown on page 54. The words "after a fashion" are used advisedly, for the reason that there is no way whatever of exactly—or even approximately—calculating the monetary value of a manure pile.

Farm manures are serviceable in several ways other than simply the furnishing of plant food. They supply humus, they physically modify a soil structure, they increase its microorganic activity. These are important functions the value of which cannot readily be measured in terms of dollars and cents, and any attempt to set forth such a value which overlooks them is justly open to criticism. Then again, no one can state how available are the plant nutrients in a given lot of manure. The nitrogen, for instance, is certainly not as available as is that in nitrate of soda; the phosphoric acid is not as likely to be as promptly serviceable for plant uses as is the soluble phosphoric acid in acid phosphate. Still further it may be remarked that the standard crude fertilizing stocks are quoted and sold on the market on the sole basis of their plant food contents, whereas sales of manure are made entirely without regard to its plant food values. And finally it may be said that owing to the untoward conditions brought about by the war, no "trade values" have been established by the station directors of the North Atlantic States since 1915. Hence it is that no attempt is made in this article to express monetary values further than to say that in 1915 Lyon, Fippen and Buckman, arbitrarily fixing the prices of nitrogen, phosphoric acid and potash at ten, two and a half and four cents a pound respectively, stated the approximate values of the plant food contents of a ton of various manures as excreted, that is to say before any admixture had been made with litter and before fermentation and leaching had taken their toll, as follows: Swine, $1.50; cow, $1.64; horse, $1.97; sheep, $2.87; poultry (dry), $4.80. Obviously the validity of these estimates depends on the validity of the assumed figures. It should not be forgotten, furthermore, that these sums are not meant to represent the agricultural value of these excreta but the value of their plant food contents rated at arbitrary figures.

A few points stand out. In the first place, it is clear that $1.50 to $2.00 is not an excessive ton price for farm manure. Then again it is evident that poultry manure is worth from two and a half to three times as much as is any other manure, barring that of the sheep. It should not be forgotten that the soil—much less the crop—may not

and usually does not benefit by these full values; far from it. The proportion which finally reaches the fields and crops is determined largely by the care and method of handling. The animal furnishes; man disposes; and his disposition is often a careless one.

PLANT FOOD LOSSES

IN THE STABLE

The first chance for loss—and it is a serious one—occurs in the stable when floors are used which are not tight. Some farmers seem to prefer loose planks. Indeed, they sometimes bore auger holes through the floor in order to help out the openings between the boards. This procedure tends to keep the floor free from much liquid and enables one to economize on bedding. But at what a cost! Fifty-one percent of the nitrogen! Eighty-five percent of the potash! A 1,000-pound cow produces yearly about 80 pounds of nitrogen in the liquid as compared with 76 pounds in the solid manure, 38 pounds of phosphoric acid in the solid and none in liquid manure and 108 pounds of potash in the liquid as compared with 19 in the solid manure. The number of days and nights which she spends in the stable determines the proportion of this amount which can be saved. If she lives seven months in the stable she voids about 47 pounds of nitrogen and 63 pounds of potash in the urine during that time, nitrogen and potash which are better and more serviceable than the same ingredients in the feces, for the reason that they are soluble. Using the monetary values shown above, these urinary voidings are worth $7.18 per cow per year. The average Vermont dairy farm carries about 20 cows. How many Vermont dairymen would fail to fish $144 out of a crack in the floor? How many Vermont dairymen are there who let much more than $144 drip through the stable floor cracks and make no endeavor to prevent the loss? Concrete gutters and bedding serve as stiches in time.

BY LEACHING

Loss by leaching is an ever present danger. Much of the plant food in the solid manure is in a soluble form, readily washed out if exposed to the weather. These losses are especially heavy in the summer because decomposition tends to change some insoluble into soluble forms. Horse and sheep suffer more than cow and swine manures because of their more open structures.

Roberts (9) placed 2 tons of horse manure (⅚ excrement and ⅙ wheat straw) in a loose pile and subjected it to the joint action of leaching and weathering. Between late April and late September, it

lost 57 percent in weight, 60 percent in nitrogen, 47 percent in phosphoric acid and 76 percent in potash. The pile contained 70.4 pounds of plant food at the outset and only 24.2 pounds at the end of the test. Two-thirds of it were wasted. During the same period, 10 tons of cow manure (93 percent excreta, 4 percent wheat straw and 3 percent of gypsum) were similarly exposed. The weight shrunk 49 percent and the nitrogen, phosphoric acid and potash losses were respectively 41, 19 and 8 percents. The pile contained 127 pounds of plant food at the outset and 98 pounds at the end of the test. Less than one-fourth was lost. The gypsum tended to inhibit fermentation and to reduce the losses, and the manure was naturally so wet that it did not readily ferment.

Voorhees (15) exposed several 100-pound lots of mixed solid and liquid cow manure in a box eight inches deep with screened perforated bottom. One lot exposed 70 days (February 3 to April 13) lost 44 percent of its nitrogen, 16 percent of its phosphoric acid and 28 percent of its potash. Another lot, exposed 50 days (August 9 to September 27) lost 69 percent of its nitrogen, 59 percent of its phosphoric acid and 72 percent of its potash. The second lot lost more heavily because of fermentation.

Hart (5) reviews an experiment in which a crop increase of 116 percent, in comparison with an unfertilized area, followed the use of a given quantity of unleached manure, whereas when an amount of leached manure containing the same number of pounds of nitrogen as were present in the amount of unleached manure was applied to the adjoining plot, the increase was only 76 percent. Voorhees (15) found that as compared with an unfertilized area a crop growth increase of 83 percent followed the use of unleached manure, whereas when leached manure was used the increase was only 48 percent. At the Ohio station (12) it was found that the use of a ton of stall manure was followed by crop growth 40 percent larger than that secured when a ton of manure exposed for some months in the open yard was used. The nitrogen in the leached manure was in a form more resistant to leaching and hence was not as well adapted to promote crop growth as was that in the unaltered product.

BY FERMENTATION

Fresh manure contains countless numbers of bacteria. They serve to break down its many and complex organic nitrogen compounds into simpler forms and to liberate ammonia or free nitrogen gas. They

work most rapidly if the manure has dried out to some extent and if it is loose so that the air can circulate freely through it. Under such conditions it is quite possible for this fermentative process to proceed until practically all the nitrogen is lost. They also rapidly act upon the entire mass and greatly reduce its bulk and weight. The extreme losses cited on the last page (57 percent in horse manure and 49 percent in cow manure exposed during the summer) were due in part to decomposition and in part to leaching.

Clearly it were worth while to try to check such losses. Manure that is kept compacted and moist so that the air is measurably excluded is not a medium in which the aerobic or air-loving bacteria work to advantage; and this class of organisms is notably of the mischief-making sort. On the other hand, when manure is kept compact and moist the proper conditions exist for the work of the anaerobic bacteria, those which live in the absence of air; and these also may prove harmful. Indeed, bacteria, so far as the manure pile is concerned, may be at once beneficial and harmful. They resemble Mother Goose's little girl, who

"When she was good was very, very good
And when she was bad, she was horrid."

These bacteria live on the organic matter of the manure. They so alter the solid manure that its phosphoric acid and potash contents are made more available for plant growth. At the same time they build into their own bodies quite a little of the soluble nitrogen of the urine and feces leachings and, as has already been remarked, they tend through their activities to promote nitrogen wastage. The net desirable result of their life-work is slightly to reduce the bulk of the manure, partly to decompose the bedding material and considerably to enhance the availability of the plant food. When manure is kept on a tight floor, is protected from leaching and is held in a compact and moist condition, the effect of anaerobic fermentation is quite apt to be a beneficial one. Some nitrogen may be lost, perhaps from 15 to 20 percent (Van Slyke), but this is far less than the toll exacted by exposure to the elements.

Shutt (11) found that when four tons of mixed horse and cow manure were placed in a weather-tight shed for three months, 55 percent of the organic matter and 17 percent of the nitrogen were lost, but that the phosphoric acid or potash contents remained intact. At the end of six months 58 percent of the organic matter, 19 percent of the nitrogen and three percent of the potash were lost. The protected manure lost three-fifths of its organic matter and only one-fifth

of its nitrogen. The nitrogen loss occurred during the first three months and probably from the outside of the pile. Doubtless in larger piles the proportionate nitrogen losses would be lessened. The resulting decomposed manure was better balanced and contained not only more plant food but more available plant food per ton.

The result, therefore, of the regulated action of anaerobic bacteria is to furnish a well rotted or decomposed manure. But it should be remembered that these bacteria are Nature's agencies for the reduction of waste organic materials to their simplest forms. If their activities proceed too long unchecked, if they do their full duty, they ultimately destroy the manure and dissipate its nitrogen. They cannot injuriously affect its phosphoric acid and potash contents except in so far as they serve to make them more soluble and consequently more liable to loss through leaching. Regulated and controlled manurial decomposition is beneficial; unregulated and uncontrolled decomposition is harmful. Regulation and control are best effected by making deep, compact piles of manure, protecting them against leaching, keeping the pile moist and spreading the manure as soon as decomposition has progressed far enough to rot the coarse litter.

The fermentation of horse manure is especially difficult to control because of its open, dry character. Decay is so rapid that its temperature may approach 140° to 150° F. This brings about a very rapid loss of ammonia as well as the destruction of the entire mass. It can be controlled to some degree by packing and by moistening the pile.

CARE

Stop leak! are the first words of the catechism of manurial care. And the best stoppers are tight stable floors, plenty of litter, covered manure sheds and the regulation of fermentation.

A good way to keep horse manure in a covered shed is to let young stock tramp it. This keeps it compact and moist and it cannot leach.

A good way to preserve cow manure is to store it in a covered shed with concrete floor and walls, so that the liquid will be retained and the entire mass kept moist. If the manure pit is slightly lower than the cow stable, the liquid may drain directly into it and a carrier used to dump the solid. If such a procedure is instituted, less bedding is required, and more moisture is present to aid in controlling the fermentation. If the stables are arranged conveniently, both the horse and cow manure may be placed in the same pit.

The size of manure pit or shed needed for storing the farm manure

can be computed when the number of animals and the days of storage required are known. A cubic foot of storage is usually allowed per mature animal per day. The manure made by 20 cows requiring complete storage for five months would need 3,000 cubic feet of storage. A shed 20 x 20 with opportunity for storage eight feet depth would hold 3,200 cubic feet. Such a building can be built for from $150 to $200.

A manure pit is the "best bet" nowadays in manure saving. From 25 to 50 percent more of the total plant food may be thus saved than in any other way, unless it be immediate spreading. This will be enough to pay for the shed in a few years and the saving will be a net gain after the shed is paid for.

CHEMICAL TREATMENT

Certain chemicals are used to good advantage in lessening nitrogen losses, more especially gypsum, kainit and acid phosphate.

Gypsum or land plaster appears to act in some more or less obscure manner so as ultimately to transform the otherwise escaping ammonia into ammonium sulphate. However, the manure must be moist enough to dissolve the gypsum before this action can take place. Gypsum is safe to use and does not injure the feet of the animals. Fifty to 100 pounds per ton of manure are recommended. From one to two pounds, spread daily on the floor of each horse stall, will lessen the ammoniacal losses and improve the stable air. Gypsum of itself is an indirect fertilizer and is sometimes used as such by direct field application.

Kainit may be used to retain ammonia, 50 pounds per ton of manure or one pound per horse per day being sufficient. It should not be sprinkled directly on the stable floor for the reason that it injures the feet. It should be sprinkled on the manure pile or, better, mixed into the manure as it is thrown on the pile. Kainit contains about 12 percent of potash and increases the total plant food content of the manure. It is not now on the market.

Acid phosphate contains perhaps 40 percent of gypsum which acts in the same manner as the ordinary product. Fifty pounds per ton or one pound per horse is sufficient. It must not come in contact with an animal's feet but should be spread over the manure pile. In view of the fact that farm manure carries a low phosphoric acid content, acid phosphate is excellently adapted to mix with manure in that it balances the composition of the manure at the same time that it

conserves nitrogen. Experiments conducted by the Ohio Station (12) show a greater increase in crop growth following the application of a ton of manure reinforced with 40 pounds of acid phosphate than from that of a ton reinforced with any other chemical.

Chemicals are not as often used to save ammonia with cow and swine manures as with horse manure. Their chief value in the former instance is to increase the plant food contents and thus to make the product a better balanced fertilizer. Acid phosphate, at the rate of 50 pounds per ton, is the best chemical to use for this purpose.

As compared with other manures, poultry manure loses ammonia very rapidly, more particularly because it contains a relatively high nitrogen content and there is more to lose, and because it is seldom moist enough to inhibit rapid decomposition. The free use of gypsum on the dropping boards and in the storage barrels will tend to lessen these losses. It has been suggested by some authors that a complete fertilizer can be made by the admixture of poultry manure with certain chemicals, thus making a combination which may be used in lieu of a purchased commercial fertilizer. The poultry manure furnishes much nitrogen to such a compound as well as some phosphoric acid and potash. A combination which sometimes has been suggested is composed by weight of 10 parts of dry poultry manure, 4 parts sawdust or dry muck, 4 parts of acid phosphate and 2 parts of kainit. The sawdust or muck serves to keep the mixture dry so it can be handled in fairly satisfactory fashion in a fertilizer distributor. It is applied at the rate of from 1,000 to 2,000 pounds per acre and should carry from 5 to 10, from 36 to 72 and from 14 to 28 pounds of nitrogen, phosphoric acid and potash respectively and contain about 0.5, 3.6 and 1.4 percents respectively of these several plant nutrients. Of course a mixture of this sort cannot be made at present, owing to the lack of kainit, which is a German potash salt.

If this scheme of handling this product is not employed, at least acid phosphate should be used in amounts varying from 100 to 200 pounds per ton of poultry manure for the double purpose of balancing it, that is to say, of fitting it the better for plant uses, and of lessening fermentation.

Manure contains too much nitrogen in proportion to its phosphoric acid content and tends, if used by itself, to cause an over-heavy growth of foliage, followed by lodging and delayed maturity.

DEEP STALLS AND COVERED YARDS

In view of the fact that fermentation losses may be most successfully combatted by keeping the manure compact and moist, the so-called "deep stall" system has much to recommend it. The floor of such a device should be tight and enough bedding should be used so that it can be kept in sanitary condition. Sheep, young stock and hogs can be kept in the pens advantageously and their manure will be practically all saved. Some farmers make the mistake of "cleaning out" such stalls, pitching the manure out a window into a loose pile where it is left for several months. It is then in the best possible condition for rapid fermentation and much of its value is lost. Deep stall manure should be kept in the pen until the time comes to spread it on the fields, and, if possible, stock should be kept upon it so that it will neither dry out nor decay to an appreciable extent.

Covered yards serve an excellent purpose for conserving manure. They are built large enough to allow the stock to have freedom of movement and abundant litter is furnished. Horse manure may be spread in the yard and the cattle allowed to remain the greater portion of the day. Roberts (10) states the case as follows:—"Whenever an abundance of straw or other coarse bedding material is at hand, and when the horns are removed from the cattle or are prevented from growing, covered yards are found to be entirely satisfactory. In these the stock may take mild exercise and be watered, while at the same time they tramp the manure and prevent its too rapid heating. If gypsum is distributed occasionally over the surface, the conditions of both yard and the manure will be benefited. A yard 40 by 60 feet suffices for 20 to 25 full grown cows. Covered barnyards give opportunity to control conditions, so that there will be no loss from scattering the manure, from tramping it into the mud, from leaching and from escape of the liquid manure, while they furnish a most comfortable place for the animals to stretch their limbs while their stables are being aired, to quench their thirst in a comfortable atmosphere * * * and they give opportunity for removing the manure when most convenient." Recently (4) it has been suggested that cows be kept in a covered yard all the time except when being milked. The objections to the system lie in the expense of building the yard and the necessity of keeping abundant bedding available at all times. Where an old shed can be remodeled it may prove economical.

COMPOSTING

The bacteria which decompose manure also work upon waste materials of all sorts. The plant food contained in stubble, straw, cornstalks, leaves, sod, kitchen garbage and the like may be made in some measure available to crop uses if they—or any of them—are compacted into a pile and moistened. There may be enough bacteria naturally present to do the work, but in order to make assurance doubly sure it may be well to place a layer of farm manure in the pile so as to start the process on its way. A two-inch covering of earth or muck should then be placed over the entire pile so that the ammonia or other escaping gases may be absorbed. Enough water should be added to keep the pile moist but not enough so that it will leach. The pile should be dished at the top the better to hold moisture. After the heap has stood six to eight weeks, it ought to be turned over so that the decomposition may proceed more uniformly. The finished product may be used in lieu of rotted farm manure. An addition of from 50 to 100 pounds of acid phosphate to the ton will improve it.

Time was when there was a compost heap on almost every farm; but in these days of the easy fertilizer, when the ready-made, ready-to-drill, quick acting, dry, cleanly, commercial goods may be had for the asking and paid for in the fall, when local fertilizer agents live on half to two-thirds of the roads in town, it is a great temptation to waste that which we have and to resort to the phosphate bag in its stead. Sometimes the plant food in a compost heap may cost more in terms of labor than it is worth, sometimes it may cost more to save and to render available its contents than to throw the waste away and to buy. At present high prices, however, one should carefully consider the pros and cons and consider whether there is not on his farm much valuable soil building material in waste form which may be piled up and utilized for crop growth.

USE

FRESH AND DECOMPOSED MANURES

The most benefit ensures when manure is applied as fast as it is made. There is never any increase, whereas there always is some decrease and at times tremendous decrease following the storage of manure, even for brief intervals. To phrase the matter another way, the manure is never better for use on most field crops than it is the moment it is voided. The writer once heard a speaker say that any day

in the year except Sundays and holidays is a good day on which to spread manure; on winter's snow (if the land is fairly level), in summer's heat. However, it is neither practicable nor advisable to follow this doctrine literally. At times the press of work is such that it needs must be stored. Then, too, there are soils and crops on which a rotted manure may do better than an unrotted manure, particularly if commercial fertilizers are not used. Hence one should know the good and the bad points of both.

Fresh manure; advantages. The largest proportion of the total plant food may be utilized when the manure is applied directly to the land. The rains and the downward pull of gravitation cause the soluble portion to pass directly into the soil. Fermentation is checked, particularly in dry weather, since the relatively small clumps dry rapidly on the surface. Shutt (11) found that when decomposing manure containing 9.8 pounds of nitrogen was exposed direct from the pile in thin layers it lost five percent of its nitrogen, while the loss was only two percent under similar conditions in manure that was well rotted. When fresh manure is plowed or harrowed in, it tends to lighten heavy soils. Its decomposition in the soil helps similarly to disintegrate sod or stubble which has been plowed under. Its soluble nitrogen content promotes rapid foliage growth. It is on this account especially adapted to application to meadows, corn fields or other forage crops.

Fresh manure; disadvantages. When coarse bedding has been used and the manures plowed under on a light sandy soil, it tends to make the soil so open that it dries out too rapidly. Then, as a consequence, the manure does not rot normally and proper root development is hindered. Furthermore, on the lighter types of soils the liquid manure may decompose so rapidly that a surplusage of soluble plant food is furnished. Plant roots may become injured or "burned" or an over-rapid foliaceous growth secured of such crops as oats or potatoes which is likely to be followed by lodging and delayed maturity. And, finally, it is well known that it is a serious weed distributor.

Rotted manure; advantages. Manure which has been stored under conditions where it cannot leach and has been kept compact and moist, decomposes more or less and, as a result, is better balanced and better fitted for the forcing of crop growth. Its mineral constituents in particular are made more available; it spreads better, for the reason that the coarse litter has been largely broken down; it exerts no ill effect on light sandy soil; and the viability of its weed seed contents is seriously affected.

Fresh manures are to be preferred on the heavier soil types, on

soils in need of humus, and on forage crops; decomposed manures are best adapted to use on the lighter soil types and on potatoes, truck crops and cereals.

SOIL RELATIONS

Farm manure is distinctly an all-round fertilizer. Not only does it supply plant food but it improves the soil in many other ways. The presence of ample supplies of organic matter or humus is absolutely essential to crop growth. Now while fresh manure is about two-thirds water, from one-fifth to one-third is made up of dry matter, that is to say of humus forming material. It well may be that in a given case the soil benefits full more by the increase of its humus content than by the application of nitrogen, phosphoric acid and potash. Indeed, some soils which carry a low humus content are brought again into good health by plowing under green crops. This procedure is not as a rule an advisable one in this section. It is a better practice to grow and to feed the crop to the stock and to restore the manure to the soil than to turn it under directly, thus securing two services instead of one. Furthermore, the potential humus in the manure generally is in better condition for crop uses than is that in the green crop.

As has been heretofore pointed out, farm manures contain countless numbers of microorganisms which induce decay. The application of manure places these myriads in a strategic position to attack roots and stubbles which have been plowed under and to cause their rapid decay, thus increasing the amount of available plant food.

The effects of farm manure on crop growth extend over a series of years. A German experiment covering four years' trials at eight different location with divers soils and rates of application indicated that 23 percent of the nitrogen, 33 percent of the phosphoric acid and 44 percent of the potash was assimilated and that, in round figures, 48 percent of the amounts assimilated were utilized the first year, and 24, 15 and 13 percents the next three years. In other words, in four years approximately one-third of the applied plant food had been utilized, one-sixth being drawn upon at the outset, one-twelfth the second year and one-twelfth the next two years. At the Rothamsted (England) station, barley was manured 20 years at the rate of 14 tons annually and then grown for 20 years without manure. "Taking as the standard of comparison the unmanured produce (which, however, itself gradually declined) * * * over the first 20 years, there was an average annual increase of 28¼ bushels by the application of the farmyard manure, and * * * over the second 20 years there was an average

annual increase of 35¾ bushels where the application was continued, and of only 17 bushels where it was discontinued" (3). The effect of the manurial applications was still quite noticeable 20 years after they were discontinued.

The maintenance of the fertilility of the land is a problem that confronts the world. Chinese and Japanese farmers have grown crops for centuries without noticeable decrease of soil fertility (16). They save all manurial and crop residues; they waste none whatever. Many American farmers who are cultivating "new lands" gather crop yields which are less by one-half than those secured on the same areas 50 years ago. They remove the entire crop, burn the straw and stubble and do not return so much as a cartload of manure to the land. *Puzzle*—Find the heathen! On the other hand many American farmers pride themselves on never selling cash crops, on feeding everything to their stock, thus keeping the fertility at home. And yet, sometimes, these same men throw the manure under the eaves and let it waste away to the nearest creek and think that they are doing their duty by the land. Many an acre of crop lands located at a distance from the barns never receives a load of manure. American farmers may well sit at the feet of the Orientals, may well learn of them the possibilities of plant food conservation.

SIZE OF APPLICATION

A farmer recently complained to the writer of his ill luck, saying that his potatoes grew "all tops and no tubers." When asked how much farm manure he used he stated that he applied "from 30 to 40 tons per acre." Thirty tons of average farm manure contain 300 pounds of nitrogen, or as much as is found in a ton of nitrate of soda. They furnish more phosphoric acid than is found in a half ton of acid phosphate and more potash than occurs in one-fourth ton of muriate. If farm manure is worth approximately $2 per ton on the basis of its plant food content, he was applying $60 worth to an acre, or at the monetary rate of one and a half tons of a high grade commercial fertilizer. It is now well understood that liberal applications are ill advised; that it were better to spread more thinly over larger areas; that eight or ten tons is a sufficient acre dosage under most normal conditions; that more than this means wastage in that the excess of available plant food, particularly from the urine, is apt to leach away and that crops cannot profit by the excess.

Furthermore, one should remember that farm manure contains more nitrogen in proportion to other plant foods than crops can use.

It is on this account that crops are apt to lodge when large applications are made. It were better to use moderate amounts of farm manure, eight to ten tons per acre, and to add some acid phosphate than to kill with kindness.

The Pennsylvania station (6) applied farm manure to a rotation of corn, oats, wheat and hay at the rate of six, eight and ten tons per acre every second year during 25 years. The average crop increase for each ton of manure was $2.16 for the six-, $1.66 for the eight-, and $1.44 for the ten-ton application. The Ohio station (12) using four, eight and 16 tons per acre applications, secured a return of $2.43 per ton for the four-, $2.19 per ton for the eight-, and $1.44 per ton for the 16-ton application per acre.

Not only does a light application afford a larger return per ton, but at the same time a larger area may be covered each year. An application of eight or ten tons once in three years should prove more profitable than one of 16 to 20 tons once in six years. A 20-ton application at long intervals gives a feast at the outset and a famine at the end, and the drainage waters profit full more than the crop.

When land is plowed for corn, followed by oats, seeded to grass the second year, and is left in hay for the next three or four years, the best use of the manure will be made to make two light applications; the first of eight or ten tons per acre on the corn, the second as a top dressing the first or second year of hay. By thus dividing the application, both secure benefit from its use. When there is not sufficient manure available to make two such applications, the crop which is thought to be the most profitable should be favored. Corn, hay and potatoes respond well, cereals less satisfactorily.

METHODS OF APPLICATION

It is well understood that farm manure usually does the best work when it is finely divided and evenly distributed. The manure spreader makes this possible, whereas when spreading is done by hand it is impossible finely to divide the manure, and it is extremely difficult to make light applications. Large forkfuls are bulky enough so that they continue to decompose and lose ammonia for several days, whereas the finely broken-up manure settles close to the soil and dries quickly; and a dried, comminuted material does not ferment.

The manure spreader saves much time. When the haul is a long one, a three- or four-horse manure spreader is to be preferred for the reason that the larger loads involve fewer trips. It is possible thus to distribute manure on the remotest fields without excessive expense.

Where the haul is a very long one, it is a good plan to draw the manure out during the winter as made and to construct a large, high, square field pile from which it can be spread very quickly at one's convenience. This method is open to the danger of loss. The piles should be built on land which is not exposed to stream overflow and their contents should be spread as early as possible in the spring in order to avoid fermentative losses.

If the land is not too uneven or exposed to flooding, the manure should be spread during the winter rather than kept piled until spring. There is more time available during the winter for this work. If one has a manure pit it is not necessary to draw it every day. It may accumulate for a while until a convenient time, a favorable day, and then a business may be made of drawing it. There are many days in winter when the snow is shallow and the weather warm. The spreader can be used then to good advantage, provided the manure has been stored where stock keep it packed so that it is not frozen solid.

Some loss of plant food occurs when the manure is spread on the snow to lie all winter, but this not likely to be greater than the loss which occurs when the pile is exposed to the weather and is less than that which is suffered by the pile exposed under the eaves. The gain in time saved offsets what slight extra loss may occur.

If the land is steep and rolling, manure should be spread and harrowed or plowed in at once. Manure left on the surface of a sidehill for the winter will lose much value by washing. When most of one's land is of this type, a good manure pit is a *sine qua non*.

Attention is called to several of the plates opposite page 64. They clearly show the inevitable effect of placing manure in small piles until some favorable time when they are spread by hand. There is nothing to recommend this checkerboard method. It takes more time and gives less returns than any other.

Differences of opinion exist as to the wisdom of plowing manure under or of spreading it and harrowing it in. When a manure full of coarse bedding is spread on the surface it may be difficult to work it into the soil, and under such circumstances it decomposes slowly. Such manures should be plowed under. On the other hand, well rotted manure breaks up in a finely divided condition and may be sufficiently well worked into the soil by the use of the harrow.

Coarse manure should be plowed under as soon as possible after being spread, for the reason that long exposure to the sun kills many of the decay organisms which it contains. This results in delay rather than in decay after the plowing is done. Field trials have often

demonstrated that a larger crop growth is secured when strawy manure is plowed under than when it is allowed to lie for several weeks on the surface before it is turned under.

In conclusion and by way of recapitulation touching the matter of manure spreading, it may be said that during the winter months manure may be spread on level lands not exposed to flooding and may be stored in well made and deep piles on uneven or flooded areas or, better, in protected manure pits to be spread as soon as the condition of the land permits in the spring, the residues, if any such there be, being applied to the lands immediately after haying, and, when ample supplies are available, at intervals throughout the fall.

The important matters to remember are the value of manure, the high proportion of this value which is located in the liquid, the ever present dangers of loss by leaching and fermentation, and the folly of wasting through over liberal usage on general farm crops. As Dean Roberts well says: "We grow a plant to feed an animal to secure manure to grow another plant." Farm manure is the third link in this chain—a vitally important link. Use it properly and the fertility of our lands will be maintained; abuse, neglect, ignore it and future generations will rise up and call us cursed.

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THE MANUFACTURE OF COMMERCIAL FERTILIZERS

by J. L. HILLS

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BULLETIN 207: THE MANUFACTURE OF COMMERCIAL FERTILIZERS

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INTRODUCTION

The modern commercial fertilizer is a somewhat complex thing. It is made from materials gathered from the ends of the earth and derived from many processes. Chili and the Argentine, Germany (in ante-bellum days) and the isles of the sea, Spain and our own Southern States are drawn upon. The products of the coke ovens, of the iron industry, of the stockyards, of the fish and vegetable oil factories, of the tanners, the hat, felt and other industries are used. Florida, Tennessee and South Carolina furnish phosphate rock; Louisiana and Texas supply brimstone. It may be said truly of the commercial fertilizer of today that its ingredients are assembled, assorted, accelerated and assimilated; assembled from Dan to Beersheba, assorted in the factory, accelerated as to their rapidity of action and assimilated in crop growth. Surely an industry which thus effectively prepares raw materials for field uses is doing a fundamental service of national importance.

Nineteen hundred and fourteen marked high tide in American fertilizer manufacture. In some 800 factories, 7,500,000 tons were made, valued at more than $150,000,000; and nearly another million tons were made in about 300 factories engaged primarily in other lines of work, making fertilizers simply as a side issue. About one-fifth of the factories are wet mixing plants, the residue do dry mixing. Seven large corporations with their subsidiary and affiliated companies make three-fifths of the entire output, two of them selling one-third of it. Much of the business, particularly in the South, is done by small dry mixing plants, working locally.

Seventy percent of the factories are located in the South, fifteen percent in the North Atlantic States, ten percent in the Middle West and five percent in the Far West. Six-sevenths of the tonnage is used in the States bordering on the Atlantic and Gulf coasts from Maine to Texas, three-fifths in the South Atlantic and the Gulf States and 99 percent east of the Mississippi River. Of the nearly 1,200 fertilizer plants in operation in 1914, according to the report of the Federal Trade Commission, 44 were located in the six New England States or a little more than three percent of the total number. Only one complete plant owning its own acid chambers was then running in New England—there are now two—and only seven plants in which acid phosphate was made.

Vermont farmers use more than 25,000 tons of commercial fertilizer yearly. The total bill is in excess of $750,000 or about two dollars

per capita. Speaking broadly, they find that it is profitable to use commercial fertilizers; otherwise they would not buy them. The old-time prejudice against them largely has passed away. Yet it is conceivable that if farmers understood more clearly just how fertilizers are made they would be the more likely to make careful choices, to use wisely and, as a result, would secure better returns.

It is on this account that the writer has thought it worth while to attempt to describe the way in which commercial fertilizers are made today. He knows of no such article in experiment station literature and feels that perhaps he is making a real contribution. It may not be amiss for him to say in this connection that he was engaged in the fertilizer business in the late eighties, having been resident chemist for a phosphate mining concern and for a fertilizer company for nearly two and a half years, thus securing firsthand information touching the trade. Furthermore for 24 years, by virtue of his occupancy of the station directorship, he has had charge of the fertilizer control in Vermont. Still further, for more than 20 years he has taught college classes something as to fertilizer manufacture and usage. And, finally, as a precedent to the preparation of this article, he has been permitted through the courtesy of the trade to visit and most thoroughly to inspect the factories and to study the processes of a considerable number of the fertilizer companies whose goods are sold in Vermont. The representatives of the trade were kindness personified and afforded him every facility for observation, courtesies which he greatly appreciates and thankfully acknowledges. He is particularly indebted to:

Messrs. Ross L. Coe, J. M. Wilson, H. J. Wheeler, C. G. Ward and P. J. Derrig of the American Agricultural Chemical Company;

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Mr. F. Perry Hubbard of the Rogers & Hubbard Company.

No attempt has been made in this article to describe any one plant or any process peculiar to a particular plant. The aim has been rather to make it broadly descriptive of the industry as a whole, a composite as it were. As a matter of fact that is about all one could

aim to do, for the reason that the manufacturing processes in the larger plants seem to be pretty well standardized.

The manuscript of this article was submitted in advance of publication to representatives of each of the companies whose courtesies the writer enjoyed, in order that it might be criticized and corrected in case of error of statement, and practically without exception their suggestions have been accepted. Galley proofs were similarly submitted to these parties and also to Mr. John D. Toll, the editor of the trade journal, the *American Fertilizer,* as well as to the writer's associates in the chemical departments of the University and Station. It seems, therefore, not too much to claim that this bulletin accurately sets forth the present process of manufacture in the factories of the North Atlantic States.

Outline of the Process

The process of commercial fertilizer manufacture involves the assembling, pulverizing, acidulating and blending of several forms of fertilizing crude stock; that is to say, many things, such as nitrate of soda, tankage, phosphate rock, potash salts, for example, are gathered and, when necessary, ground; some of them acidulated (dissolved) with sulphuric acid in order to render their plant food contents more available and allowed to heat, dry and "cure"; they are then thoroughly disintegrated and commingled by several processes, bagged and shipped. Simply stated, but less simply done! A large plant usually is needed, unless the manufacturer buys his acidulated rock in the form of "acid phosphate," in which event he does what is known as "dry mixing" and his plant may be large or small as the size of his trade dictates, consisting primarily of mixing and storage houses and shipping platforms.

A large modern factory in which the so-called "wet mix" process is used comprises several buildings, including

1. *The acid plant;* including burners (brimstone or pyrites), lead chambers, with their accessories, towers (Glover and Gay-Lussac); storage for brimstone or pyrites and for acid; acid eggs and pumps.

2. *Storage, mixing, shipping plant;* including storage room for the many crude ingredients, mills for grinding phosphate rock, bone, etc.; wet mixer for acidulating the rock and other ingredients entering into the so-called "base-mix"; so-called "dens" in which the secondary stages of the wet-mix process are carried out; the great piles where the various wet mixed goods are deposited to complete the "curing

process" from which, if already containing all the ingredients needed to make the finished product, they are in the course of time removed, again thoroughly disintegrated, commingled and made mechanically perfect, bagged and shipped; or, more commonly, from which they are withdrawn for the addition of other ingredients; the dry-mixing mechanism, wherein the various fertilizer crude stocks with the utmost thoroughness with the acid phosphate or the base-mix as the case may be; the weighing and bagging mechanisms; the shipping platforms; and sundry subsidiary mechanisms, including tracks, cars, cranes, loading devices, scales, etc., etc.

3. Wharves, sidings, unloading mechanisms, repair shops, offices, chemical laboratories, etc.

THE RAW MATERIALS

Let us at the outset, before we start on our tour through the factory, get clearly in mind what are the things with which the manufacturer deals, what he uses for crude stock from which to manufacture his finished goods.

They are primarily carriers of available nitrogen, phosphoric acid and potash to the crops. They are, in the main:

Nitrogen conveyors. Nitrate of soda, sulphate of ammonia, calcium cyanamid, calcium nitrate, dried blood, tankage, meat meal, concentrated tankage, guanos, fish scrap, cottonseed meal, castor pomace, tobacco stems, garbage tankage, hoof meal, etc., treated leather, felt scraps and peat.

Phosphoric acid conveyors. Phosphate rock (acidulated, making so-called "acid phosphate"), spent bone-black (acidified, making so-called "bone-black superphosphate"), basic slag.

Nitrogen and phosphoric acid conveyors. Ground bone, (raw, steamed, extracted), bone tankage, leached guanos.

Potash conveyors. Muriate of potash, sulphate of potash, kainit, sundry minor German potash salts, etc.

The following brief description of these materials is inserted at this point in order to make the article more complete. Very full statements as to the nature of these several forms of crude stock will be found on pages 298 to 312 of bulletin 182, which will be sent to any address without charge, for the asking.

NITROGEN CONVEYORS

1. *Nitrate of soda* (Chili saltpeter) is made from a crude salt mined in the Chilian deserts. It is soluble in water, highly available, and commonly carries from 15 to 15.5 percent of nitrogen.

2. *Sulphate of ammonia* is a by-product of coke-oven and illuminating gas manufacture. For several years it has been used to a considerable extent in the manufacture of the fertilizers sold in Vermont. It is soluble in water, readily available and commonly carries from 20 to 20.5 pecent of nitrogen

3. *Calcium cyanamid* is an artificial product derived from the air, the nitrogen of which is held to be promptly changed into ammonia in the soil and to be quickly available to plant growth. It contains about one-half its weight of actual cyanamid and one-fourth its weight of slaked lime. It is a light, fine, dull gray to black powder carrying about 15 percent of nitrogen.

4. *Calcium nitrate* is another atmospheric product, carrying from 12 to 14 percent of nitrogen. Its use in this country thus far has been very slight. It is soluble and available.

5. *Dried blood* is simply the evaporated, dried and finely ground blood of slaughtered animals. It is a high grade product, probably under ordinary circumstances the most available source of organic nitrogen and is second only in this respect to mineral nitrogen. It is highly variable in composition. Red blood may carry from 13 to 14 percent of nitrogen; black blood may run nearly or quite as high as or may carry much less nitrogen than the best red blood.

6. *Tankage* is the trade term applied to the dried and disintegrated residue of a rendering process whereby packing house products not otherwise used—bone, flesh, blood, tendons and other offals—are cooked under heavy steam pressure in closed steel tanks to remove the fat and make the product friable. It is naturally and inevitably quite variable in composition, according to the preponderance either of bone or of meat, ranging from 4 to 12 percent of nitrogen and from 7 to 20 percent of phosphoric acid. The availability of the nitrogen and particularly of the phosphoric acid in tankages, other things being equal, is held to depend largely upon the fineness of grinding. A true tankage, if finely ground, is an excellent source of available nitrogen.

7. *Meat meal* (azotin, ammonite) is produced from dead animals. slaughter house offals, etc. It is made in much the same way as is tankage and carries from 10 to 14 percent of nitrogen.

8. *Concentrated tankage,* or "stick" as it is sometimes called, is the evaporated liquor residue from the tankage process above described. It carries about 12 percent of nitrogen which is of relatively high availability.

9. *Guanos* consist mainly of the excreta of sea-fowl or bats, together with their feathers, bones and bodies more or less altered as a result of exposure to the elements. In rainless climates they dry out but otherwise are not profoundly changed; in moist climates they suffer the loss of their more soluble constituents. Hence it is that some of the Peruvian guanos carry from 12 to 15 percent of nitrogen and as much phosphoric acid, whereas West Indian guanos contain little or no nitrogen but have a high phosphatic content. Bat guanos vary widely in composition, in some instances being almost entirely devoid of plant food while at other times they contain much nitrogen and phosphoric acid.

10. *Fish scrap* is a term commonly applied to the principal by-product of the menhaden fish-oil factories. It carries as a rule from 7 to 10 percent of nitrogen and from 5 to 12 percent of phosphoric acid. The higher percentages occur only in scrap containing unusual proportions of heads or bones. The availability of the nitrogen is fairly high.

11. *Cottonseed meal* is the ground by-product of the hulled and hydraulically pressed cottonseed, carrying from 6 to 7 percent of nitrogen, a little more than 2 percent of phosphoric acid and barely 2 percent of potash.

12. *Castor pomace* is the ground by-product of the castor oil industry. Its nitrogen content ranges from 5.5 to 6 percent and it ranks high among ammoniates as to availability. It carries about 2 percent of phosphoric acid and from 0.5 to 3.5 percent of potash.

13. *Tobacco stems* (the stalks and midribs) are excellent sources of nitrogen and potash. They carry from 3 to 3.5 percent of nitrogen, much of it in the form of nitrate, and from 4 to 9 percent of potash, mostly in water-soluble forms.

14. *Garbage tankage* is derived from the rendering of city garbage. Its nitrogen content varies from 2 to 3 percent, that of phosphoric acid from 1.5 to 3 percent, and of potash from 0.5 to 1.5 percent. It is used to some extent in fertilizer manufacture as a "conditioner." When put through the so-called "wet-mix" process (pages 28-35) its availability perhaps is somewhat enhanced: when used in an unacidulated form in a dry-mixed goods, its immediate service in crop growth

under the climatic conditions obtaining in the North Atlantic States is probably small.

15. *Horn, hoof and hair.* Hair and feathers carry from 14 to 15 percent of nitrogen; tannery hair, half as much. They decompose rather slowly and, unless they are subjected to the wet-mix process, are not likely to prove available sources of nitrogen. Hoof meal contains somewhat less nitrogen than hair, but when steamed and ground to extreme fineness, it furnishes a fairly available source of nitrogen. Horn meal ranges from 7 to 15 percent in its nitrogen content. It is usually disintegrated under steam pressure before use and its nitrogen availability presumably is increased by this means.

16. *Wool waste, shoddy and felt refuse* are byproducts of the woolen mills, hat manufacturing establishments, etc. They may be rich or poor in nitrogen which is more or less readily available according to circumstances; if wet-mixed, they are doubtless considerably improved in respect to their nitrogen availability.

17. *Leather,* raw, steamed, acidulated, roasted, or otherwise especially treated, carries usually from 7 to 9 percent of nitrogen and traces of phosphoric acid which are usually deemed to be but slowly available. Certain modern processes now in common usage tend decidedly to enhance the availability of leather.

18. *Peat,* dried and ground, is used more or less as a "filler" or "conditioner." A "conditioner," it may be well to explain, is a material used for the dual purpose of keeping the finished product in a dry, and hence a favorable mechanical condition and of lessening the likelihood of undesirable chemical reactions taking place after mixing. Peat contains usually from 1 to 2.5 percent of nitrogen, which is relatively inert and but slowly available to plant growth.

The trade makes use today of organic nitrogenous crude stocks of a sort which would have been anathema in the earlier days of the trade. Wool wastes, shoddies, leather scraps and kindred materials of animal origin, if put through the wet-mix and den process, are doubtless decidedly improved as to their nitrogen activities, although they may not be made equal in all cases to the better grades of organic nitrogen. However, in view of the limited supplies and high prices of organic ammoniates, the proper use of these better products and byproducts of processes which tend to make the nitrogen of such material reasonably available to plant life is to be encouraged. (In this connection see pages 35-37).

PHOSPHORIC ACID CONVEYORS

1. *Bone* appears in many forms; as raw bone, steamed bone, bone ash, boneblack, etc.

(a) *Raw bone* (usually called "raw bone meal") is the term applied to bone ground either in the strictly raw and untreated condition or after a slight boiling. It carries usually more than 3 percent of nitrogen and 20 to 25 percent of phosphoric acid which are somewhat less quickly available than the same ingredients in steamed bone.

(b) *Steamed bone* (usually termed in the trade "fine ground bone," or "pure fine ground bone" in contra-distinction to "raw bone meal") is the product of steam pressure treatment, which removes more or less of the glue, gelatin and fat. Its nitrogen content may be reduced as low as one percent and its phosphoric acid content may be raised as high as 30 percent. Ordinarily these figures range from 1 to 3 percent of nitrogen and from 20 to 30 percent of phosphoric acid. Steamed bone is more friable and finer than raw bone and, being relatively fat-free, disintegrates more rapidly in the soil.

(c) *Bone ash* consists merely of the ash of burned bones. The chief supply now comes from the South American pampas. It carries no nitrogen but contains 30 to 35 percent of phosphoric acid.

(d) *Bone-black* is simply a bone charcoal. This material formerly was used in large quantities in sugar refineries for the clarification of sugar juices and is now employed to some extent by oil distillers. Modern sugar refinery processes dispense in the main with this product and it does not cut the figure it once did, either in the sugar refining or in the fertilizer trade. It enters the latter as "spent bone-black" after it has become worn out for sugar cleansing purposes. When dissolved with sulphuric acid, it is known as "bone-black superphosphate" or "dissolved bone-black" and carries a high content of available phosphoric acid, usually about 17 percent.

2. *Basic slag* ("odorless phosphate," "Thomas phosphate," "slag meal") is an iron furnace byproduct, the pulverized slag of Bessemer steel converters, wherein pig iron which contains phosphorus is converted into phosphorus-free steel by the basic process. It carries usually from 17 to 19 percent of phosphoric acid, which is relatively available though not soluble in water. It also contains 40 percent or more of lime, most of which is combined with phosphoric acid and silica.

3. *Phosphate rock* occurs in many parts of the world. It is sometimes of strictly mineral origin, sometimes a modified animal

debris of bygone geological ages, sometimes simply a leached guano. Large commercial deposits occur in the United States, more particularly in Florida, Tennessee and South Carolina, carrying from 55 to 80 percent or more of "bone phosphate of lime," equivalent to from 25 to 38 percent of phosphoric acid, all in insoluble form. Immense and high grade deposits occur in Utah, Idaho, Wyoming and Montana, but these are not now being worked, being located on government lands and at points which are less accessible to the trade than are the still ample southeastern supplies. Under normal conditions 80 percent of the American rock is mined in Florida, 16 percent in Tennessee and 4 percent in South Carolina; and 48 percent of the world's production is of American and 39 percent of North African origin.

4. *Acid phosphate* (superphosphate) is the trade name applied to the product resulting from the treatment of ground phosphate rock with sulphuric acid, a process which renders most of its phosphoric acid content soluble in water and some soluble in the weak soil acids, leaving, if the work is properly done, only a small proportion in its originally insoluble condition. While phosphate rock is commonly used for this purpose, the process is equally applicable to bone, tankage and spent bone-black. Three grades of acid phosphate are now commonly offered, guaranteed respectively to carry 16, 14 or 12 percents of available phosphoric acid.

POTASH CONVEYORS

The main source of potash for fertilizer purposes has been in former years the potash salt mines near Stassfurt, Central Germany. No known deposit of a similar extent exists elsewhere. Nowadays fertilizer manufacturers are hard put to it to secure a sufficiency of potash. Relatively small quantities, mainly as sulphate, are being obtained in Nebraska, Utah and California. The following statements, 1 to 6 inclusive, refer to the German salts which in bygone days were used in the fertilizer trade—which let us hope in the near future again may be used provided an equally good, plentiful and cheap American source cannot be developed.

1. *Muriate of potash* is made from the crude German salt "carnallit," by a process of solution and crystallization. It usually carries from 48 to 51 percent of potash, all soluble in water. Prior to the outbreak of the war, muriate was the cheapest available potash in American markets and the main source of the potash used in fertilizer manufacture in the North.

2. *Sulphate of potash* contains from 47 to 50 percent potash, and is made by solution and crystallization or precipitation from the crude German salts "carnallit," "kainit" and "kieserit." It is now being made in a relatively small way from western deposits in Nebraska, Utah and California.

3. *Double manure salt* is a combination of sulphates of potassium and magnesium, carrying about 25 percent of potash, and is made from German salts.

4. *Potash manure salts* is a trade name for low grade muriate, carrying about 20 percent of potash.

5. *Kainit* is a crude German salt, unprepared save by grinding. It consists mainly of potassium and sodium chlorids and magnesium sulphate. It is guaranteed to furnish 12 percent of potash and was quite often used in low grade brands in ante-bellum days. It is highly esteemed in the South.

6. *Hartsalz,* a crude German salt, occasionally has been imported. It is unprepared except that it is finely ground.

7. *Carbonate of potash* occasionally is seen in the trade.

8. *Tobacco stems* carry from 4 to 9 percent of potash, mostly in water-soluble form.

9. *Nitrate of potash* sometimes has been used as a source of nitrogen and of potash, although generally it commands too high a price for use in the fertilizer trade.

10. *Cement works cinder and dust* are now being used to some extent. They carry from 9 to 10 percent of potash.

THE FUTURE AS TO RAW MATERIALS

The greatest known phosphate rock deposits are in Utah, Idaho, Wyoming and Montana. Their contents seem to be fully 25 to 30 times as great as those of the Florida and Tennessee mines combined. The domestic potash production appears at present to be confined to California, Nebraska and Utah. And the "best bet" on the commercial fixation at atmospheric nitrogen seems to be the great western water powers and the low grade coal beds of Montana, Wyoming, Utah, Colorado and Idaho, both largely undeveloped. Now, distance lends enchantment to the view but enhancement to freight rates. Hence it is, that with an eye to the future, attention is being given to the preparation of concentrated raw materials and fertilizers. Some of these methods have not as yet been worked out in a commercial way, but progress is being made. A product carrying nearly 70 percent of the phosphoric

acid of fertilizer parlance is being made; and ammonium and potassium phosphates and combinations of the two are being manufactured, the latter being said to carry about 5½ percent nitrogen, 57 percent phosphoric acid and 19 percent potash.

THE MANUFACTURING PROCESS

It is assumed for the purpose of this article that the factory makes no crude stock whatever. As a matter of fact, several factories control phosphate rock mines, in Florida or elsewhere, the product of which enters the factory as a crude stock. Several make their own tankages, steamed bone, garbage tankage, etc. In view of the fact that the methods of manufacture of these materials have been discussed recently in full in bulletin 182, pages 298 to 312, which is still available without charge on request, they are not reviewed at this point.

THE FOUR KINDS OF FERTILIZER FACTORIES

There are in a sense several kinds of commercial fertilizer factories. There is the complete plant with its own acid chambers; the plant which buys its acid but grinds its own phosphate rock and acidulates it; the plant which makes ammoniates only and buys its other materials, having neither acid chambers, rock grinding nor acidulating mechanisms; and, finally, there is the straight dry-mixing plant which buys all its crude stocks prepared for mixing and commingles them much as the farmer does when he home mixes chemicals on his barn floor, except that it is on a much larger scale.

The first sort as a rule are the big fellows; the second often but not always are large concerns; the third, with rare exceptions, are relatively small manufacturers; and the last are usually small concerns, although sometimes, especially in the South, they make a considerable output. About an eighth of the companies manufacturing in the United States own acid plants, about an eighth buy their acid, one-sixteenth make ammoniates and buy the residue of the crude stocks, while more than two-thirds buy all their crude stocks and do a dry-mixing business. The goods made by 12 of the 18 licensees selling in Vermont are made in factories which produce their own acid; in three instances acid is bought; and in two instances the plants make organic ammoniates, buy acid phosphate and other ingredients and practice dry-mixing.

It should be clearly understood that there is no necessary difference between the grade or serviceableness of the output of plants

of these several sorts. Chamber acid is chamber acid whether made on the premises or made at some distance and brought to the factory in tank cars. Acid phosphate made within the factory walls where it is used in nowise differs from acid phosphate made, let us say, in Baltimore and shipped to a New England factory for mixing in the dry condition with other fertilizer ingredients. A brand made in a dry-mixing plant is usually quite as effective in promoting crop growth as one which is made in a "complete" factory; and there is no reason why it should not be exactly as effective, provided the nitrogen in the organic ammoniates used in the dry mixing is relatively as available. The ingredients of dry-mixed goods, commingled in a very small plant making a limited tonnage, perhaps a few hundred tons a year—there are none such whose products are sold in Vermont, but there are many such in the South—mixed with shovels, possibly may not be quite as intimately mixed as if they had been handled by mechanical means, but this is not necessarily the case. Certainly this is not the case with the larger dry mixers who use disintegrating machinery and make thoroughly well mixed goods. The determination in a given instance whether a factory shall be of one class or of the other is decided by considerations other than those affecting the character of the output.

SULPHURIC ACID MANUFACTURE

The first portion of the complete fertilizer work to be studied is naturally the acid plant. Sulphuric acid is an absolutely necessary item in the manufacture of the modern commercial fertilizer since by its use the phosphoric acid in the phosphate rock which otherwise is so insoluble that it is of relatively little use in securing prompt returns in plant growth is made available to plant uses.

Sulphuric acid is the most important artificial chemical substance manufactured in the world. Most of our chemical industries directly or indirectly are based on its manufacture. It is used in the main in the fertilizer industry (which, in ante-bellum days consumed about 60 percent of the entire production in this country), in the refining of petroleum products, in connection with the iron, steel and coke industries, in the manufacture of soda ash, bleaching powder, soap, glass and a multitude of other products, chemical and metallurgical, and, in immense quantities of late, in the manufacture of munitions. Indeed, the insistent call of the explosives trade for acid has greatly increased its price to the fertilizer and every other trade and by reflex action ballooned that of acid phosphate.

There were approximately four and a half million tons of chamber acid made and used as such in the United States in 1916 and a million tons of concentrated acid, about 200 plants being employed for the purpose. These are scattered all over the country but are located mostly in the East, in or near our larger cities on waterways, railroads or both. Their product was worth about $35,000,000. So great a demand has arisen for concentrated acid in connection with munition manufacture that concentrating devices of several kinds have been recently constructed. In view of the fact that concentrated acid plays no part whatever in fertilizer manufacture, no mention need be made of these adjuncts.

A modern sulphuric acid plant may cover an area of several acres and cost upwards of a half million dollars. The manufacturing process is a complicated one and necessitates careful and expensive supervision. It is so costly a proposition as regards initial investment, management and upkeep that acid plants are installed only at the larger factories.

Sulphuric acid is made from:

(a) Either brimstone (pure or nearly pure sulphur), or iron pyrites (a combination of iron and sulphur, mined in many parts of the world but mainly—so far as American fertilizer manufacture is concerned—in Spain).

(b) Nitrate of soda.

(c) Water.

(d) Oxygen (air).

(a) *Brimstone* or native sulphur is found in many parts of the world. The supply used in American acid plants is derived usually from Louisiana and to some extent from Texas. Ninety-eight percent of the entire American product comes from this locality. Sicily is the only other important commercial source. This subterranean deposit usually is worked by an ingenious process whereby a superheated steam at 165° C. (330° F.) or thereabouts is forced down a tube in order to melt the sulphur while compressed air is used to drive the condensed water and melted sulphur to the surface where the latter cools and settles. It is about 98 percent pure.

Iron pyrites, a more or less pure di-sulphid of iron, is of world-wide distribution. Virginia, California, and a few other states, and Canada furnish about 650,000 tons annually of a grade containing about 40 percent of sulphur. The Spanish pyrites, which are usually employed in acid manufacture in the North Atlantic States, though temporarily difficult to get owing to disturbed freight conditions, carries from 45 to 50 percent of sulphur, all but about two percent of

which can be utilized in the burning of the ore. It is used in two forms, as coarse "lumps" which are broken before burning to about the size of "egg" coal, and "fines," that is to say the very fine particles or dust of pyrites mining, analogous to but finer than the "pea" or "buckwheat" coal of anthracite mining. These two forms are chemically identical though mechanically unlike.

In some sections (Tennessee, New Jersey, Illinois, Montana, Arizona) zinc sulphid (blende) or copper sulphid (copper pyrites) are used in making sulphuric acid, notably by the zinc and copper smelting concerns; but, with one exception, they are not thus employed in the East. Nearly one-fourth of the normal output of chamber acid is thus derived. The Tennessee copper smelters in particular make relatively immense quantities.

(b) *Nitrate of soda* which is used simply as a carrier, as is set forth on pages 19-20, is described briefly on page 8 and more fully on page 299 of bulletin 182, which is free for the asking.

(c) *Water* is supplied as steam or as a fine mist spray.

(d) *Air* is supplied mechanically by the draft created by the burning sulphur.

The essential parts of an acid making plant for a fertilizer factory[1] in the order of their usage, are:

(a) The burners.
(b) The niter pots.
(c) The Glover (concentrating and denitrating) tower.
(d) The lead chambers.
(e) The Gay Lussac (absorbing and recovering) tower.
(f) The concentrators.
(g) The eggs or pumps.
(h) Acid coolers.
(i) Gas circulating fans.

Sulphuric acid (H_2SO_4) is formed as a result of the chemical union between water (H_2O)—as steam or water vapor—oxygen (O) from the air, and sulphur dioxid (SO_2) gas derived from the burning of sulphur either as pyrites or brimstone. The combination cannot take place, however, with these agents only at work and sulphuric acid can only be made by the chamber process through the agency of nitrogen oxids acting as oxygen carriers, as it is set forth on pages 19-20.

[1] About one-tenth of the acid made in the United States is produced by the contact process which does not involve the use of lead chambers. No fertilizer factory is thus equipped, the process not being deemed to be adapted to this purpose.

(a) *The burners.* Burning sulphur fumes consist chemically of sulphur dioxid or sulphurous acid (SO_2), the same choking gas formed by the burning of the head of the old fashioned match. The burners vary as to their form according to the nature of the fuel, be it brimstone, pyrites "lumps," or the so-called pyrites "fines" or dust. Brimstone burns easily, the main difficulty encountered being the control of sulphur volatilization. Once the burners are fired pyrites burn readily, the heat derived from the sulphur and iron oxidations maintaining the process. The brimstone or pyrites (lumps) furnaces consist of banks or batteries of burners placed side by side in long rows charged one after another at intervals, say, of 12 hours and so arranged that continuous combustion is carried on for months, indeed, for years at a time, thus providing a constant and regular evolution of the gas. The new charges are placed on top of the partly burned ore and the cinder removed from beneath the grates. The brimstone and the lump pyrites burner batteries look something like a series of small boiler furnaces without boilers (See Plate I, figure 1). A "fines" furnace consists of a vertical cylindrical steel shell lined with fire-brick, with seven or more horizontal brick hearths or shelves placed one above the other, over each of which revolves a series of steel arms with rabble teeth. These toothed arms continuously feed the fresh dust in at the top and down into the flame and on each hearth continuously turn and plow the burning ore, thus opening it up so that the combustion may be more complete and the gases more readily escape. The spent ore is discharged at the base of the cylinder. Elaborate cooling devices serve to keep the mechanism within temperature bounds. Whatever the form of the furnace and regardless of the nature of the material burned, the product is the same, namely, sulphurous acid (SO_2), an acrid, gaseous product of sulphur and oxygen combined in the proportion of one to two by volume and one to one by weight.

If the burners are properly managed the evolved gas contains from six to eight percent of sulphurous acid (SO_2) and about 12 percent of oxygen—although if brimstone is being burned these figures may be increased by half. This is enough in each case, in connection with the water vapor, to form the final product, sulphuric acid.

The gases mechanically carry over with them more or less "flue dust," composed of sulphur, if a brimstone burner is used, and of oxid of iron, arsenic, lead, zinc and other materials occurring in the raw ores if a pyrites burner is employed. This is in part scrubbed out by the tower process and otherwise and by the Glover tower's acid coolers,

and in small part is carried onwards into the chamber. Every effort, particularly when "fines" are burned, is used to prevent the dust from reaching the chambers, dust arresters, baffle plates, etc., being employed for the purpose.

The burner gases, at a temperature which may vary from about 525° to 720° C. (950° to 1300° F.) pass through a large flue common to the entire burner system, over the niter pots, through the Glover tower and on the lead chambers.

(b) *The niter pots.* These are great cast-iron pots placed in connection with the burner-flues between the burners and the Glover tower. Nitrate of soda and sulphuric acid are fed into these pots from time to time as needed. Sometimes a solution of nitrate of soda of 15° B. strength is used in lieu of the solid nitrate. The strong sulphuric acid replaces the weaker nitric acid and, combined with the soda, forms a solid residue of sulphate of soda, the so-called "salt cake" which is usually a waste product. The main product of this chemical reaction, namely, nitrogen trioxid (N_2O_3), pours over the edge of the pots as a heavy red-brown gas and is swept forward and into the strong onward current of sulphurous acid and oxygen.

Sometimes instead of introducing the nitrogen trioxid gas into the system by the potting method, nitrate of soda is sprayed in water solution directly into the chambers, or nitric acid as such is admitted into the Glover tower. However, these modifications of the process are not in common usage.

The function of the nitrogen oxids which are thus evolved and which shift about in the chamber space from one form to another and back and forth in strange and temporary combinations with the gaseous molecules, is that of an "oxygen carrier." The sulphurous acid (SO_2) must be converted into sulphuric acid (H_2SO_4) and can only thus combine if an oxygen carrier is employed which of itself does not enter into the chemical combination but transports or transfers the needed molecule. The writer has been accustomed to liken the function of the nitrogen oxids in this connection to that of the clergyman officiating at a marriage, a necessary factor in the union but not himself a participant. Once his blessing is pronounced the couple is one and his duty is done. Now sulphurous acid and oxygen can come together in the bonds of sulphuric acid only if joined together by the oxygen carrier, the nitrogen oxids, which simply unites them and steps aside. Furthermore, the same molecule may and does function in this manner thousands of times, may and does join thousands of molecules of sulphurous acid to as many of oxygen; and so may a clergyman repeat

over and over again the marriage service with multitudes of loving couples. The writer hesitates to carry this analogy any further, however, for the reason that sulphuric acid is one of the stablest unions known, whereas ———

The nitrogen oxids, as will be noted later, sweep onward through the lead chambers and are in the main recovered by the tower system for further use as oxygen carriers. Theoretically, the tower system working in a normal way should absolutely inhibit nitrogen oxid losses, but practically the loss necessarily incident to the process approximates one pound of nitrate of soda for each 40 pounds of sulphur burned. An experienced acid maker tells the writer that a wastage of not

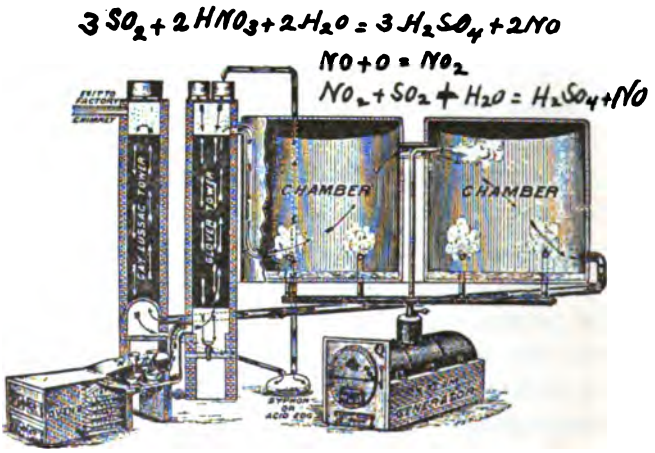


FIGURE 1.—A schematic picture of a sulphuric acid plant, showing general arrangement of burners, niter pots, towers, lead chambers, steam generators and acid egg, as well as the chemical reactions, reduced to the simplest terms, which are thought to take place in its manufacture. This view was drawn 20 or more years ago. It is not a strictly correct portrayal of a modern plant. Neither is the statement of chemical equations necessarily exact or in accordance with modern conceptions. This statement was written nearly 25 years ago on the picture from which this cut was made. Lunge's reactions are $SO_2 + HNO_3 + O = (HO)(NO_2)SO_2$. $2(HO)(NO_2)SO_2 + H_2O = 2H_2SO_4 + N_2O_3$

to exceed 3½ to 4 percent is considered to indicate good work. It is because of this relatively small but necessary wastage that the niter pots have to be recharged and fresh nitrogen trioxid introduced into the chamber about once every half hour.

Now nitrate of soda is expensive. It is an important item in the ultimate cost of the chamber acid. Its recovery is important, its usage in just the right amounts, no more and no less than are needed to oxidize the sulphurous acid, is carefully guarded. Constant attention must be paid to the regulation of the air or oxygen and water inlets, since excess or shortage of either or both would be likely to lessen the

ability of the nitrogen trioxid to do its full service in converting sulphurous into sulphuric acid and to cause undue losses.

The internal regulation of these relationships is still further secured by a careful oversight and control of the temperatures throughout the chamber system, especially in the first chamber; by noting the color of the gases in the chambers or connecting pipes through windows or "sights" introduced for this purpose; or, in some plants, by frequent determinations of the sulphurous acid content of the chamber gases and of the ratio it bears to the available nitrogen oxids at different points in the chamber system; and, finally, by experience. If, for example, the temperature of the first chamber runs higher than normal, the probability is that too much nitrate is being used, whereas, if it runs too low it is likely that an insufficiency is being used. Over usage of nitrate is highly undesirable, not only on account of the wastage but because of the fact that the acid fumes if in excessive quantity tend to dissolve the sheet lead and rapidly to destroy the chambers.

(c) *The Glover (concentrating, denitrating) tower.* The hot (520°-720° C., 900-1300° F.) gases, composed of sulphurous acid, oxygen and nitrogen (air from the burners) and the nitrogen oxids from the niter pots, pass onwards to the Glover tower. This device is a tall, upright cylindrical or square tower, usually 8-12 x 8-12 x 25 feet or thereabouts, built of heavy lead sheets and lined with acid-proof brick, or built of special acid-proof brick, and packed in pigeon-hole or corncob fashion with large fragments of an especially hard variety of quartz, obtained usually from a certain quarry in North Carolina, or with coke fragments, or, perhaps more commonly, with a special acid-proof brick. All these materials are heat-proof and acid-proof. The hot gases in passing upwards bubble through a falling shower of relatively dilute sulphuric acid which is evenly distributed by an ingenious device made of lead and located at the top of the Glover tower in such manner as to cause the fluid uniformly to cover and to trickle down during its fall over the entire packing. The acid used in the Glover tower is a mixture of the "nitrous vitriol" or "nitroso-sulphuric acid" from the bottom of the Gay Lussac (pages 24-25) and of chamber acid, the one relatively concentrated, perhaps 60° Baumé (77.7 percent acid), the other relatively dilute, perhaps 50° Baumé (62.2 percent acid). The mixture which starts at the top of the Glover at about 54° emerges at the bottom at about 60° Baumé, becoming considerably concentrated during its downward passage.

Now this tower serves five distinct purposes:

(1) The cold and falling rain of nitroso-sulphuric acid cools the hot burner-gas fumes rising through the packing material so that they enter the lead chamber system at a much lower temperature than would otherwise be the case. Hot fumes attack the lead viciously; cooler ones are less active.

(2) The hot fumes drive off much water from the relatively dilute acid and thus serve to some extent to concentrate it.

(3) The moisture driven off from the dilute acid is returned to the chambers for further work.

(4) The acid thus heated cannot retain the nitrogen trioxid gas which was absorbed in the nitrous vitriol in the Gay Lussac tower (pages 24-25). It is therefore released and reenters the lead chambers along with the burner gas and oxygen and again resumes its former functions as a bearer of oxygen and transformer of sulphurous into sulphuric acid.

(5) Incidentally a little sulphuric acid is formed in the tower by the oxidation of the vapors.

The Glover tower, in short, cools the fumes, thus lengthening the life of the chambers, concentrates the acid, prevents moisture and nitrogen oxid wastage, and makes a little acid. It is a sentinel, a policeman, an efficient operator. The acid from the base of the Glover tower, which was a nitroso-sulphuric but which once more has become ordinary strong sulphuric acid, having accomplished its five-fold purpose, is again pumped to the top of the Gay Lussac tower once more to begin its round, to exercise its policeman-like activities and to arrest escaping nitrogen oxids. In fact, much of the acid used in the two towers is a constant and unchanging supply which passes back and forth from the bottom of one tower to the top of the other on an endless round, never entering the plant proper.

(d) *The lead chambers.* These immense structures make up the great bulk of the acid plant. They are usually four in number—often with intermediate lead towers, "reaction towers," or coolers or mixers of various sort—set in twos, side by side, sometimes 100 or more feet long, perhaps 30 feet wide and 20 feet high. The modern tendency is to make smaller chambers, 40 to 50 feet long, and more of them in a group. The cubical contents of a set of chambers may range from 100,000 to 300,000 cubic feet. The relation of chamber space to burner capacity should be approximately 11 cubic feet per pound of sulphur burned daily. The chambers are built of sheet lead weighing from six to eight pounds per square foot. These sheets are welded together by the process known as "lead burning," using a blow-

pipe. That is to say, the edges of the sheets are melted and run together and not soldered. This is done for the reason that only lead will withstand the corrosive action of acid. Neither brick, wood, iron, cement nor any other building material can be used for this purpose. Indeed, lead itself is not fully resistant as the frequent necessity of patching indicates. However, a well built and well cared for set of chambers should last from 15 to 18 years. The great weight of the chambers is supported by exterior wooden or iron frame work and on cement or brick piers. The chambers are not built in the form of a tight box, but are so constructed that the sides are neither fastened to nor touch the bottom but are set down as it were near to or within the continuation of the bottom raised up as an edge along the sides. If one simply pictures in his mind's eyes a shoe box, cover side down, one gets the idea, and in a general way likewise the relative dimensions of a chamber. The so-called joint is "sealed" before the chambers are started into operation by the use of a sufficiency of chamber acid to form a liquid seal. This peculiar method of construction is employed in order to allow for expansion and contraction. Thermometers are inserted and drips arranged at various points along the system so that the operator may know what is going on. Temperature readings, hydrometer tests of the strength of the acid, and chemical analyses showing the proportions of sulphurous and of nitrous acids at given points, furnish the main indications of the successful operation of the chambers. (See Plate I, figure 2).

Into the first chamber of this system by way of the Glover tower and, sometimes, an auxiliary cooler or "reduction tower," pour the hot mixed gases. A constant mist of water is thrown into the top of the first as well as of the succeeding chambers by means of a fine spray device, using a platinum tip spray. Sometimes, but less commonly nowadays than formerly, steam is used instead of a mist spray. In some plants steam is used in the winter and the mist spray in the summer. More water than is really needed to make the chamber acid is thrown into the system, in order surely to convert as nearly as may be all of the sulphurous into sulphuric acid and in order that a too concentrated acid may not be made which would tend to absorb undue amounts of the nitrogen oxids. The gases and the water vapors pass slowly onwards through the great chamber system and its intermediates, forced along their way in the main by the draft caused by the tower action, in part by forced draft, in part by the currents caused by the chemical reactions. The waste products pass out of the system by way of the Gay Lussac tower.

The reactions which take place in the chambers are complex and none too well understood as to their intermediate stages. The ultimate result, however, is obvious, namely, a dilute sulphuric acid, the so-called "chamber acid," about two-thirds full strength or, in acid-making parlance, of 50° Baumé. If care is used, if the temperatures are well controlled, and if the quality of the gas content is frequently checked by analysis, it is quite practicable to convert into acid 98 per-cent of the sulphur which is burned, and the nitrogen oxids, too, are recovered with but little loss. The reactions occur among the gases and the water mists or vapor while they are in as it were a nebulous state, which explains the necessity of such vast spaces in the lead chamber system. It must contain furthermore the immense amount of free nitrogen contained in the air which passes through the burners in order to supply the needed 12 to 15 percent oxygen. The sulphuric acid, formed as a mist in the chamber space, drops as a liquid to the floor. The reactions occur all along the line, in all the chambers, the gases cooling, however, as they pass onward toward the outlet.

(e) *The Gay Lussac (absorbing or niter recovering) tower.* This device stands at the exit of the system in much the same manner as its mate, the Glover tower, stands at the entrance. It, too, is a detective, a "stop thief." Its peculiar function is to prevent the escape of the nitrogen oxids, the chemical clergyman alluded to on page ——. This tower in its construction features is in most respects a duplicate of the Glover (pages 21-22), though often somewhat higher, 35 to 45 feet. Its size is determined by the cubical contents of the chambers, that is to say, by the work it has to do. A downpour of cold, strong acid, as in the case of the Glover tower, meets an uprush of chemical fumes. These gases comprise the atmospheric nitrogen which passes through the entire system from burner inlet to Gay Lussac outlet, untouched, uninfluenced, a mere diluent, the excess of oxygen necessarily carried in order to make certain that as nearly as may be no sulphurous acid molecule may escape oxidation, perhaps a half of one percent which does escape is the best one can do, and, finally, the nitrogen oxids. The acid which is distributed at the top and rains downward through the tower and trickles over its packing is the moderately concentrated acid, perhaps four-fifths strong, pumped from the bottom of the Glover tower coolers after having performed the five-fold service as set forth on page 22. Now this acid dissolves the escaping nitrous fumes, and becomes nitroso-sulphuric acid, or the so-called "nitrous vitriol," arresting almost but not all of it. Small quantities pass onwards and out into the air, appearing as red-brown fumes

emerging from the top of the tower escape pipe; fumes the hue of which Oliver Wendell Holmes—the poet, not the justice—long ago likened to that of the cheek of a blushing maiden—presumably the "nut-brown maiden (who) hath a ruby lip."

A sulphuric acid plant is as amenable to weather changes as is a barometer. Its nitrogen oxids recovery is decidedly affected by meteorological conditions. In stormy weather the outcome is not as likely to be satisfactory as it is when the sun shines.

The nitrous vitriol pumped to the top of the Glover tower is relieved of its valuable burden on its downward passage through that device, as is set forth on page 22, and the nitrogen oxids are started again on their round through their chambers.

Stated briefly, the theory of the tower system is based on the fact that hot and relatively strong acid will not retain in solution the nitrogen oxids which cold strong acid readily absorbs.

(g) *"The Acid Eggs" or Pumps.* Obviously the final product has to be transported to the place where it is to be used. The common transporting agency employed for this purpose is the so-called "acid egg," a cast-iron siphon arrangement, either egg-shaped or round, or else a special pump, usually of a centrifugal type. The conducting pipe may be of cast-iron or lead lined but usually is heavy two- or three-inch lead pipe. (See Plate VIII, figure 1).

(f), (h), (i). *The concentrators, acid coolers, gas circulating fans.* The concentrators have little or nothing to do with the manufacture of chamber acid, which alone is used in fertilizer manufacture, though they bear relation to the maintenance of the acid used in the tower system. Hence there seems to be no need of describing them in this article. The service of the acid coolers and gas circulating fans is sufficiently indicated by their titles.

Strictly speaking, the utlimate product of this process is not sulphuric acid, i. e., a full strength and chemically pure sulphuric acid, but a dilute, commercial, more or less impure material, the so-called "chamber acid," ordinarily containing about 65 percent acid and being of a 50° Baumé strength. This is cheaper to make than the strong acid, which is concentrated from the original dilute chamber product, and is much to be preferred in the manufacture of fertilizers. Not only does it cost less but it works better. The strong acid is viscous, flows heavily and does not readily penetrate the mass of ground rock; and furthermore, the tendency is for the calcium sulphate to form in envelope fashion around particles or pellets of the ground rock, thus

shielding them from acidification. On the other hand the use of an over-dilute acid results in making so thin and soup-like a product that it is hopeless to expect to secure a good mechanical condition in the finished goods.

Let us now, having observed the method of the manufacture of the sulphuric acid, pass over to the mixing plant.

ROCK GRINDING

As a rule, the crude stocks from which a commercial fertilizer is made, with the exception of the phosphate rock, the bone and the coarser ammoniates, enter the factory in condition for direct use, either in the wet- or in the dry-mixing process. Rock and bone, however, need to be ground in powerful mills of large capacity.

Several forms of rock mills are used, rolls and rings, rollers, rolling balls, pestle and mortar, etc., being used as pulverizing agencies. The roller type is perhaps as widely used as any form, whereby the crushed rock, about as large as walnuts, is still further crushed by steel rollers revolving within a steel ring. Buhr mills are sometimes used. So far as may be, friction and wear and tear are minimized and the rock fragments are caused to abrade and crush one another. Rapid speed, centrifugal action, and fan blasts are employed, and heavy hardened steel grinding and impact surfaces are used. The essential features of a good rock mill are durability and simplicity of construction and handling, low power and upkeep charges, and a large output of finely ground rock. As a rule, manufacturers say that 80 to 90 percent of the rock should pass a 60-mesh sieve, having about 3,500 holes per square inch. Some seem to be more particular than others as to the fineness of grinding. In some factories the writer could scarcely feel grit in passing the ground rock through his fingers. It approximated the "feel" of flour. Fineness of grinding has an important bearing on the completeness of the subsequent acidification, on the amount of acid needed, on the rapidity with which the product dries out and on the proportion of the phosphoric acid which is left undissolved, although it must be said that these seem to some extent to be factors of the type of rock used, its hardness, its carbonate of lime and its iron and alumina oxid contents, etc. Rocks carrying a low carbonate and a high oxid content are acted on slowly by acid and are finely ground, whereas when carbonate is present in considerable quantity a coarser mesh may be used. Florida rock is harder than Tennessee rock and, speaking in general terms, it may be said that from one and one-half to two tons of the

latter can be ground in the same time as one of the former. The finer the product the less the acid is needed to "cut" the rock. When rock costs more than acid it is not usually ground as finely as when it costs less. (See Plate II).

The capacity of a mill is governed, of course, by its size, the character of the rock which is ground and the fineness of grinding. Some mills grind two to three tons an hour, some large ones upwards of 20 tons. Probably from five to twelve tons represent the normal capacity of the types and sizes usually employed.

Modern rock mills, run as they generally are by electric power, and possessing proper fan accessories, are not as dusty as they were in olden times, but they are necessarily noisy. In fact modern fertilizer factories as compared with the plants of a generation ago are relatively dust-free, fume-free and odorless. Not that they are immaculate parlors—far from it; but much care is taken to see to it that the mills and mixers are dust-tight, partly because of health considerations and partly for the reason that the dust contains a valuable plant food and is worth saving.

Bone mills are less powerful mechanisms than rock mills. They are really crushers rather than mills, designed to reduce to convenient size large fragments which are sometimes tough and sometimes relatively friable, which later are ground in a Buhr mill or some other disintegrating mechanism. The dust from the bone crushers or mills, being organic, is not pleasant to breathe and, being finer and lighter in specific gravity than rock dust, settles less readily. However, as has just been remarked, all modern factories are solving the dust and gas problems in an increasingly satisfactory fashion.

ACID PHOSPHATE MANUFACTURE

The rock and bone being ground, the next step is their acidification. This is done in order that the phosphoric acid may be rendered available. It exists in rock or bone chemically united with three molecules or parts of lime. When acidified two of these three are torn from their combination to unite with the sulphuric acid, leaving but one molecule or part held in its original form. Now one molecule or part of lime is not strong enough, so to speak, to keep the phosphoric acid from passing into solution when it gets a chance. And that is why the acidification process is used, the most characteristic, the central process of commercial fertilizer manufacture, the making of the phosphoric acid available to plant uses. Sulphuric acid is used for this

purpose because of its strength and cheapness, and because the residual product of the reaction, namely sulphate of lime, takes up the excess of water necessarily present in the chamber acid and forms gypsum or land plaster, thus making an article which readily dries out and becomes pulverulent.

THE WET-MIX PROCESS

As has just been explained, acid phosphate is made by the intimate admixture of finely ground phosphate rock (page 26) and of dilute sulphuric acid (page 17). A "base-mix," which is a combination of organic ammoniates, usually of the lower grades, and of phosphate rock with sulphuric acid, is similarly concocted. The process is an essential, perhaps the essential, feature of the factory. Given the analysis of the rock, its contents of phosphate of lime, of carbonate of lime, and of iron and of aluminum oxids, as well as the degree of fineness to which it has been ground, and the strength and temperature of the "chamber acid," which is usually 50° B. or 1.53 sp. gr., the proper proportions may be calculated readily which, when commingled, will serve to make a dry, friable, and highly soluble product. When Florida rock is used the proportions commonly run not far from equal parts. Tennessee rock, however, usually requires a little more acid than the same weight of Florida rock. In no case is enough acid used to make all the phosphoric acid available, for the reason that so much would be needed that the goods would be damp and sticky. In other words, an incomplete job is done in order that the product may be mechanically in usuable condition. Conversely, it is unwise to use too little acid. The golden mean sought is as high an available phosphoric acid content as is practicable consistent with good mechanical condition; solubility without sacrifice of usableness. This optimum is best determined by frequent determinations of the chemical compositions of the rock as well as of the insoluble phosphoric acid content of the green goods fresh from the den.

The factory superintendent in the past has been quite content to make his acid phosphate in a somewhat haphazard fashion. When the writer was in the business in the late eighties weekly analyses were made of the rock as well as of the finished green goods, but careful computations and comparisons were not often made. Nowadays, however, close chemical check is kept upon the entire operation. The factory superintendent and chemist realize that they have to deal with definite chemical reactions; with the conversion of tricalcium phos-

phate (phosphate of lime) into monocalcium phosphate (furnishing soluble phosphoric acid) and calcium sulphate (from which gypsum or land plaster is formed); of iron and aluminum phosphates, of more or less complicated forms into iron and aluminum sulphates and—probably—free phosphoric acid; of calcium carbonate (carbonate of lime, the same thing as limestone) into calcium sulphate, carbon dioxid (carbonic acid gas) and water; and of calcium fluorid into hydrofluoric acid and calcium sulphate. They know how much acid of a given strength will serve the purpose, that, theoretically, 1.016 pounds of 50° B. chamber acid will "cut" a pound of tricalcium phosphate, that about 1.57 pounds are needed for treating a pound of either calcium carbonate or iron phosphate, and approximately 1.93 and 2.02 pounds for a pound of aluminum phosphate or calcium fluorid respectively. They know that an increase or decrease in the specific gravity or in the temperature of the acid will modify the acid usage. They can readily calculate the theoretical amount needed in a given case if the full analysis of the rock shipment is in hand. And they likewise know, as has been indicated above and for the reason there set forth, that the full theoretical acid dosage rarely should be used. A Florida land pebble, now largely used in eastern factories, carries about 70 percent phosphate of lime, 6 percent of carbonate of lime and 2.5 percent of iron and aluminum oxids. If there is much of either iron or aluminum oxid or both present, the acid phosphate does not dry well, is sticky and hard to handle. More than four percent—sometimes more than three percent—is undesirable.

The wet-mix pan is always located high up above everything else, so that its output may flow by gravity and thus save labor. The ground rock reaches it by means of an endless elevator chain and the acid is forced to it by the eggs or pump (page 25). The mixture is made in a large, castiron, round shallow pan, which may be anywhere from five to eight feet in diameter, from 15 to 24 inches deep, with capacities ranging from 40 to 75 cubic feet, and capable of holding from two-thirds of a ton to two tons at a batch. It is so arranged that, driven by pinions, it rotates on a horizontal plane, while at the same time either one or two agitators or stirring devices, carrying a series of small shovels, or plows as they are technically called, revolve rapidly and stir the mass. These stirrers are driven by bevel gears. Various ingenious devices are in use whereby the ground rock and acid loads are flowed in, the mixture dumped, the evolved noxious gases (chlorin, fluorin) scrubbed out and the steam and carbon dioxid

removed. The mixer is always covered by a "hut" or "hood" so as to lessen the likelihood of accident from acid splashing and from gas inhalation. The desired weight of finely ground rock is poured in and, just after the flow has started, the stream of acid, weighed or measured in a lead-lined tank, is run in simultaneously and the mechanism is started. The great pan revolves horizontally and the single or double sets of shovel-plows, located on the periphery of a small wheel or "spider," vigorously stir the mixture which seethes, bubbles, foams, steams, and rapidly assumes the appearance of a very hot and somewhat sticky Brobdignagian mud pie. It may weigh a ton or two, according to the size of the mixer. When the reaction begins to calm down somewhat, and when, as judged by experience, a sufficient time has elapsed, usually from two to three minutes, a central plug is lifted, a scraper lowered, the shovel action reversed—all by a single lever pull—and in a single revolution of the pan the steaming semi-fluid mass is dropped into a closed chamber located on the floor below and immediately beneath the mixer, a chamber known as the "den." The plug is then lowered, the scraper raised, the shovel-plows turned back again and the next batch of ground rock and acid, which was being weighed or measured while the preceding lot was being mixed, is made ready to be poured into the mixer. Barring breakdowns, once it is set going the mixer is kept continually at work. (See Plates III and IV).

When phosphate rock and sulphuric acid meet in the mixer pan several things happen. The carbonate of lime is converted into sulphate of lime (gypsum, land plaster) and the carbonic acid gas is driven off; small percentages of chlorin and fluorin are evolved, the latter as hydrofluoric or as hydrofluo-silicic acids, virulently acrid gaseous products, which are condensed in all or nearly all factories: the phosphate of lime is, as it were, torn asunder, some of the lime being converted into sulphate and some left still united with the phosphoric acid, in the manner set forth on page 27; and a considerable amount of water is evaporated.

It is generally held that in acidulating phosphate rock there is nine percent shrinkage due to the evolution of steam and of carbonic acid gas; that is to say, that a ton of rock and acid introduced into the mixer will yield about 1,820 pounds of cured acid phosphate.

Now the sulphuric acid which is used in converting the carbonate of lime in one sense is lost. It plays no part in making phosphoric acid soluble, which is the fundamental reason for the carrying out of the process. Yet on the other hand the acid used in the destruction

of the carbonate is not actually wasted because of the decidedly favorable effect exerted by the chemical reaction upon the mechanical make-up of the finished goods. The reaction gives rise to great heat, and the carbonic acid, seeking to escape as a gas, raises the mass and makes it porous and spongy in much the same manner as the yeast acts on a well risen loaf of bread, and as a consequence the mass dries better. A five to seven percent carbonate of lime content works well. If much more than this is present the usage of acid is excessive, while if much less is present the mass does not get hot enough to dry out satisfactorily. The iron and aluminum oxids act more particularly in causing the soluble phosphoric acid to revert, and, if in too large quantities, especially the iron oxids, the rock is rendered unfit for use. They are a nuisance and the smaller the percentage the better.

In the factories visited by the writer the acid is commonly used at a somewhat high temperature, ranging from 50 to 60° C (120° to 140° F.) being drawn continually from the acid chambers. Some manufacturers, however, lay less stress than others on the matter of temperature, using it just as it happens to come, hot or cold, winter or summer; and some prefer a cold acid. It is probable that to some extent this is a matter of habit and that the quality of the rock is also an important factor to be considered. A highly carbonated rock heats quickly and froths readily, indeed if treated with hot acid the pan may overflow. On the other hand hot acid is distinctly called for when iron and aluminum oxids are present in considerable quantities. A naturally slow reaction is thus hurried, time saved and there is no danger of premature cooling. If not of the right strength the acid is diluted to a 50° Baumé at 60° F., although a higher strength upwards to 55° B. is sometimes employed, especially if the iron and aluminum oxid contents of the rock run high. Dilution serves, furthermore, to heat the acid and thus to augment its ability to do good work.

The so-called "den" system was devised several years ago, more particularly for two reasons, namely, as a means of saving time and as a means of saving lives. A dry, pulverulent product of higher quality can be made in much less time by this system than by recourse to the old style open dump. The reactions take place more rapidly and more completely and reversion is not apt to be so serious a factor. Then, too, the objectionable, irritable, even poisonous fumes, necessarily driven off by the action of sulphuric acid on phosphate rock, do not pass into the atmosphere to the detriment of animal and plant life, but are removed by fan and flue systems and by washers or scrubbers.

The initial cost and operating expenses incident to the den system are greater than those pertaining to the open dump method. The construction charges are considerable in the first case and nothing in the other; and an extra handling of the product is necessitated when the den is used. However, it is generally held by the more progressive Northern manufacturers of wet-mixed goods—including all of those whose goods are sold in Vermont—that the advantages above outlined are worth the extra outlay.

The den is a tightly sealed space made of wood, brick or concrete. Sometimes it is not a very large chamber, perhaps 8 x 10 x 10 feet, but often it is much larger than this, from 20 to 30 feet wide, 40 feet long and 20 to 30 feet high. In any event ordinarily it is calculated to hold a normal day's mixing. The larger dens hold 200 to 400 tons. It is located on the floor immediately below the mixer. Sometimes the mixer is so located that it may deliver into more than one den. The hot semi-fluid mass, which may enter the den at a temperature approximately 120° C. (250° F.) usually remains there over night or sometimes for 24 hours, depending upon the rapidity with which the reactions proceed and the speed with which the mass dries out. Steam, carbonic acid gas and fluorin compounds pass out of the mass into the stacks provided over the wet-mix apparatus and are condensed or otherwise removed. The den is then opened and the hot mass, semi-dried, semi-pulverant, its gypsum to some slight extent in some cases "set," often nearly as hot as boiling water is removed. This is accomplished either by automatic means or by direct shoveling into cars which run on high trestles or into great clam-shell scoops controlled by aerial cranes, whence it is dumped upon the storage pile, there still further to cure. The men who empty the dens are doubtless of the salamander type, for the mass is still extremely hot. They generally wear wet cloths or sponge-filled gas masks or aspirators in order to protect their lungs against the steam and acid vapors, although there is no danger in any case of their being "gassed," since one side of the den is always opened. In some instances, the hot gases are carried off rapidly by means of suction fans. However, at best the operation is a disagreeable one and is fraught with some element of danger. Constant precaution has to be taken lest masses of the loosened material fall upon the laborers. Sometimes a den is emptied through its floor upon a hopper or an acid-proof apron carrier and pan conveyer, from which the product is transported to the storage pile. (See Plate IV).

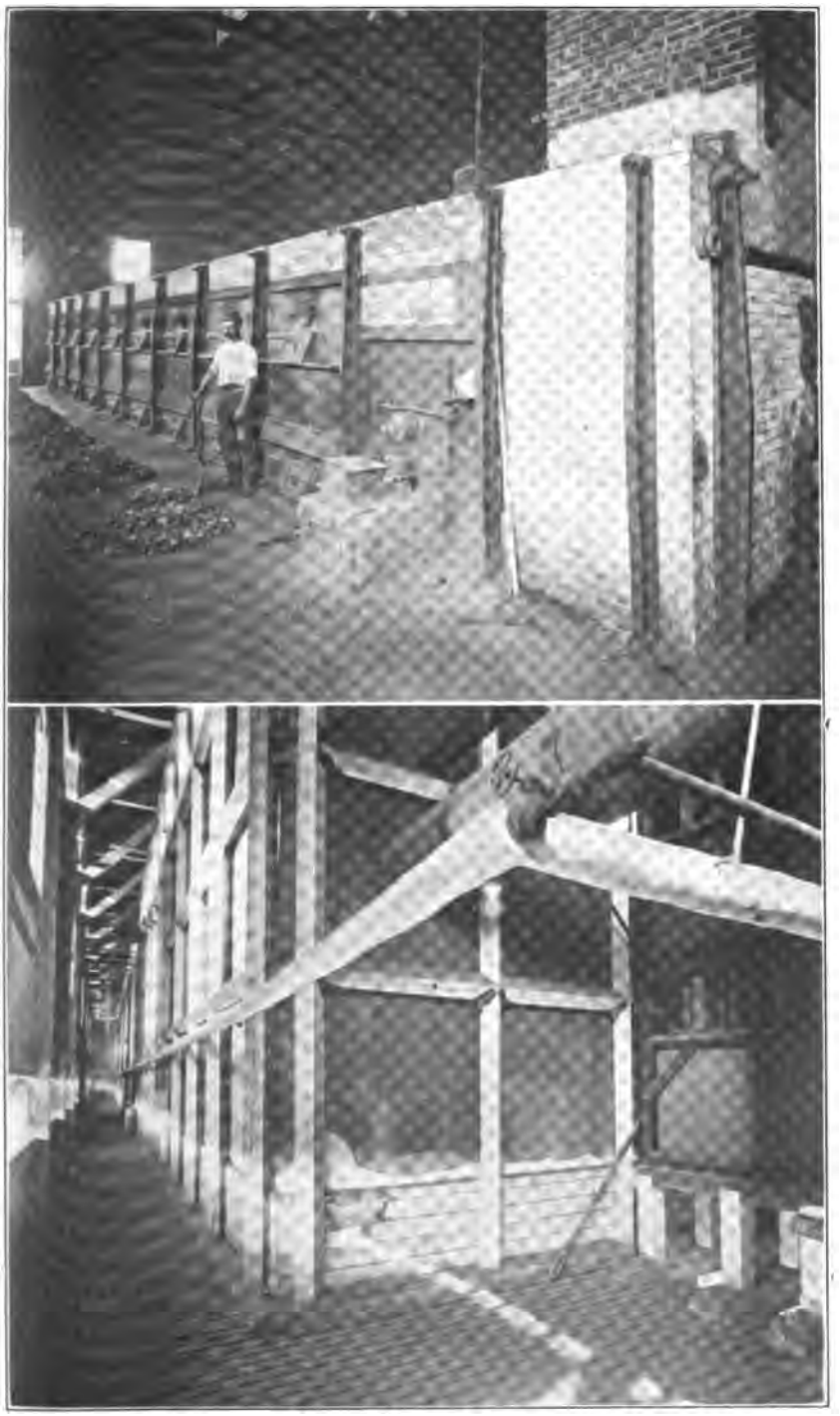


PLATE I—*Features of a sulphuric acid plant.* Figure 1. A set of pyrites burners, with niter-pot-charging door in near foreground and bottom of Glover tower in immediate foreground. The next charge of coarse lump pyrites for each furnace lies ready for use. (See page 18).

Figure 2. A detail of a lead chamber. Note the gas pipe at top of picture; the cooler-condensor system at extreme right; the "patch" put on a leaky place in the lead by "lead burning" in the center of the picture. (Page 22). (Courtesy of the York Chemical Works, York, Pa.).

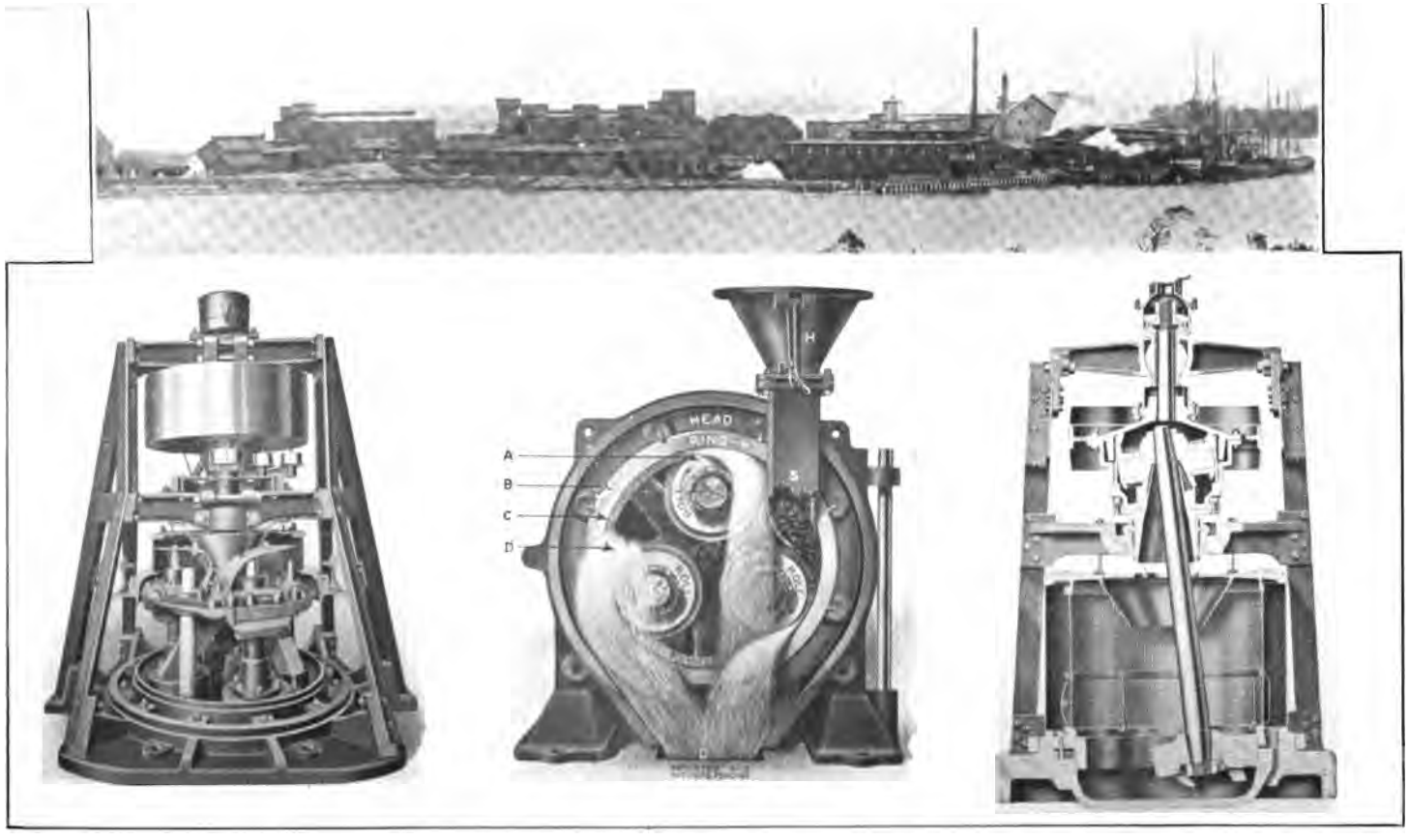


PLATE II—Figure 1. *General view of a commercial fertilizer factory.*

Figure 2. *Phosphate rock mills.* Cross section of a "three-roll" mill (left) wherein the grinding is done between the horizontal steel rolls at the bottom of the picture and the steel annular ring and bottom, the crushing being done by the centrifugal action of the rolls. (See page 26).

Cross section of a "ring-roll" mill (center) wherein the grinding is done between the steel rolls and ring as indicated. The outer ring (B) revolves, and against the unground rock held against its inner face the rolls (A) press elastically and with great force being revolved by it. The particles before they are pulverized are centrifugally held at and revolved about the periphery (C), while the "fines" (D) fall from the rings into the exit chute. (See page 26)

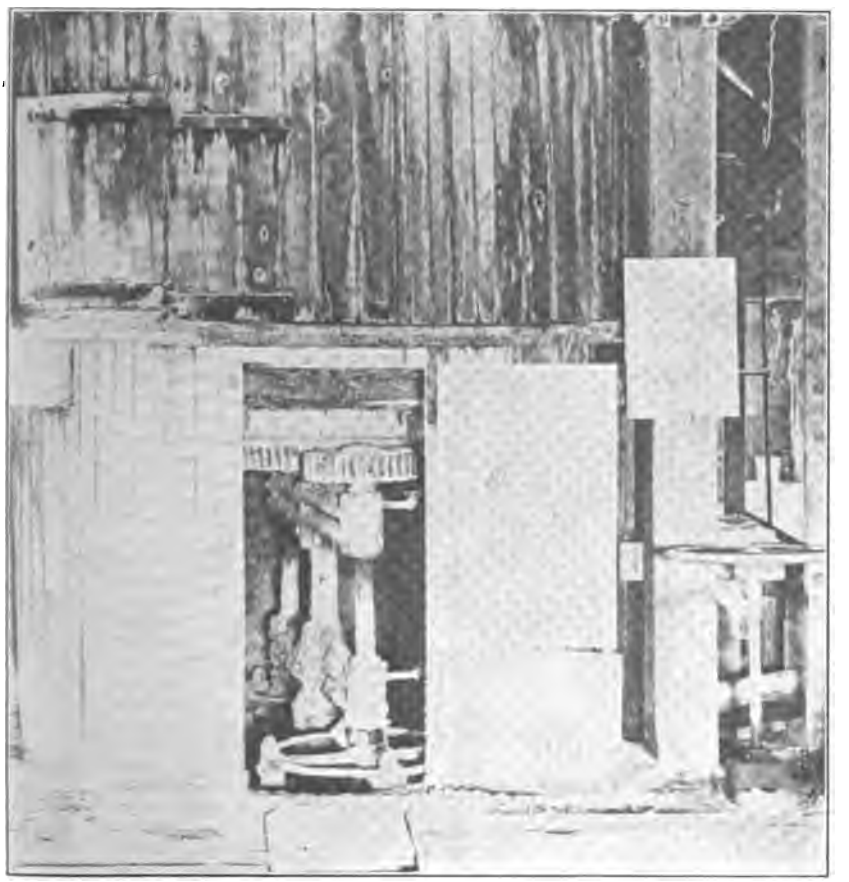


PLATE III—*The wet-mix and base-mix process.* Figure 1. A simple form of the wet-mix pan, showing exit plug (center), shovel-plows (to right of plug), scraper (to left of plug—elevated) and a "batch" of mixed goods, ready to be dumped. The pan revolves horizontally. The larger factories always use pans which carry more than one set of shovel-plows and are more complicated and effective than this simple form. (Page 29).

Figure 2. Looking into a wet-mix pan hut. Note the two wheels, one in front, one in the rear, to which the shovel-plows (out of sight) are affixed; the pinion gearing above which runs them; the mass of acid phosphate or, perhaps of fluorin compounds coating the horizontal pipes; the wheel (at extreme right) which controls the mechanism; the overhead acid tank; the tally sheet at the right of the door. (Pages 29-30).

PLATE IV—*Grinding, wet-mix machinery and dens.* The rock mills are located out of sight at extreme right, driven by electric motor; the wet-mix plant is located, also out of sight, on and below the upper floor to the right and behind the post in the foreground; and the dens are seen in part beyond the central post. In the left rear is dimly seen a portion of a dry-mixing mechanism. (Pages 26 to 37).

PLATE V—*A view in a storage shed*, showing piles of acid phosphate, of base goods or of finished goods. A portion of a dry-mixing outfit is shown on the extreme left, the elevator being "skinned," showing the bucket chain. Either a dry-mix is being made or, a mixed goods is being remilled prior to shipment. (See pages 37 to 43).
(Courtesy of the York Chemical Co., York, Pa.).

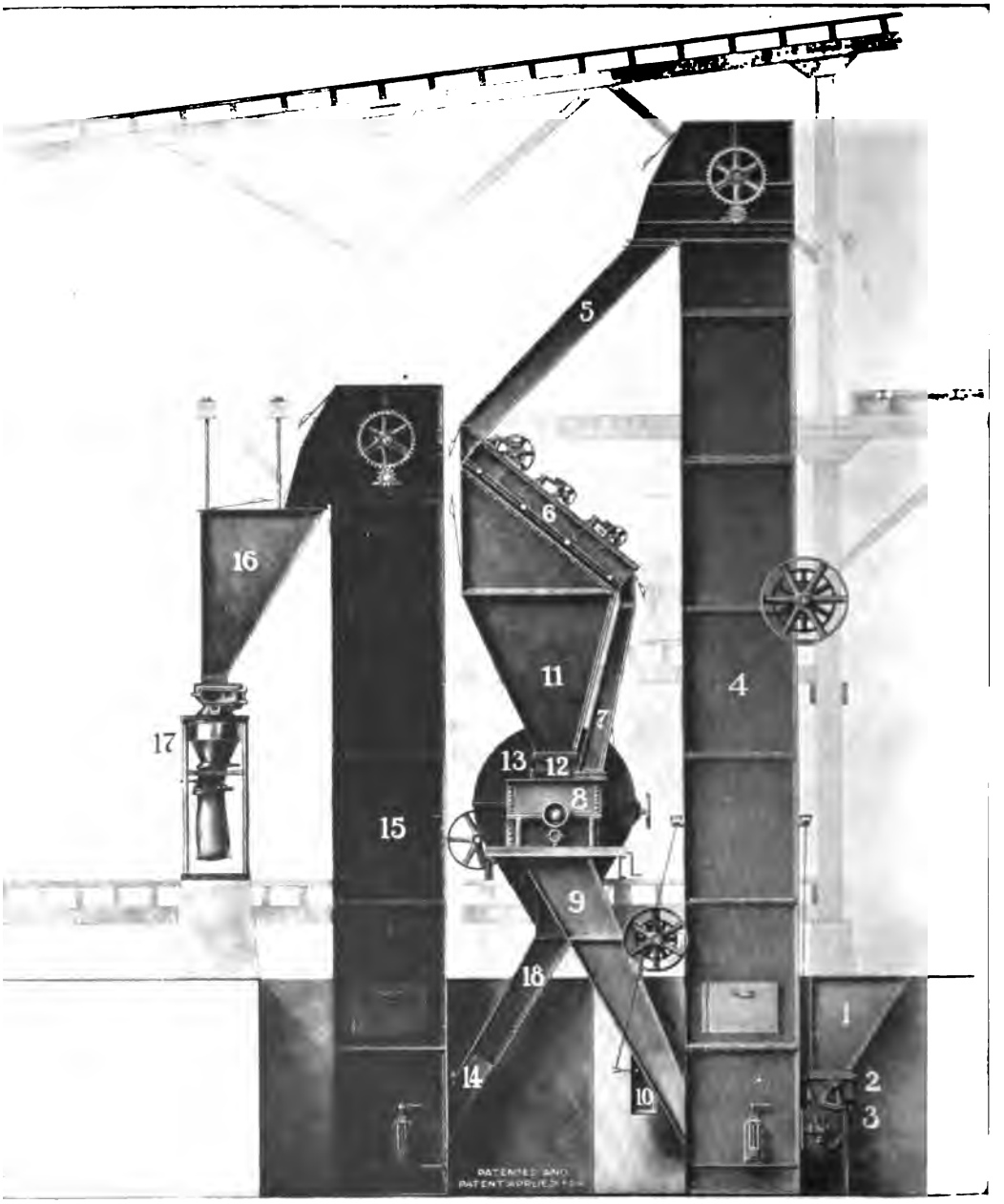
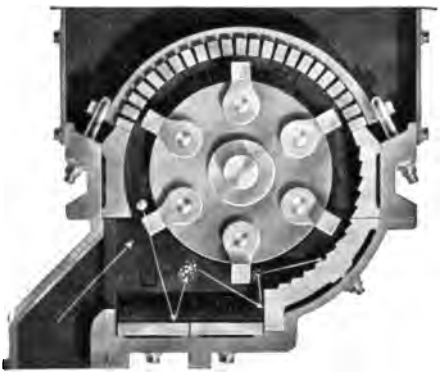


PLATE VI—*A dry-mixing plant*, wherein the several forms of crude stock are commingled. 1. Assembling hopper. 2. Clean out. 3. Breaker feeder. 4. Elevator. 5. Chute to screen. 6. Vibrating screen. 7. Chute for tailings (i. e. coarse particles) to pulverizer. 8. Pulverizer. 9. Chute from pulverizer back to bottom of first elevator. 10. Clean out. 11. Mixer hopper. 12. Mixer hopper gate. 13. Mixer. 14. Chute from mixer to discharge to elevator. 15. Elevator. 16. Bin over bagging scales. 17. Automatic weighing and sacking machine. 18. Chute from mixer hopper to bottom of second elevator. (See pages 38 to 43).

(Courtesy of the Sturtevant Mill Co., Boston, Mass.).



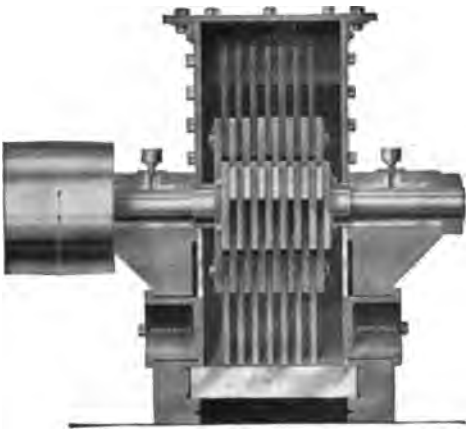


PLATE VII—*Detail of a dry-mixing plant.* Figure 1. Breaker feeder (Plate VI, 3). Figure 2. Hammer bar pulverizer (front view) (Plate VI, 8). Figure 3. Automatic weighing and bagging mechanism (Plate VI, 17). Figure 4. Hammer bar pulverizer—"side view." Figure 5. Dry mixer, cross section (Plate VI, 13). Figure 6. Another form of dry mixer. (See pages 38 to 43).

Figures 1-5, courtesy of the Sturtevant Mill Co., Boston, Mass.; Figure 6, courtesy of the W. E. Austin Machine Co., Atlanta. Ga.

PLATE VIII—*Sundry accessories.* Figure 1. An "acid egg" (page 25). Figure 2. An aerial "clam shell" scoop and acid phosphate piles (page 43). Figure 3. Vibrating screen (Plate VI, 6) (page 40). Figure 4. A mechanical loader used for digging into storage piles (page 43).

Figure 1, courtesy of the Bethlehem Foundry and Machine Co., South Bethlehem, Pa.; Figure 2, of the Shepard Electric Crane and Hoisting Co., Montour Falls, N. Y.; Figure 3, of the Sturtevant Mill Co., Boston, Mass.; Figure 4, of the Link-Belt Co., Chicago, Ill.

The change which goes on in the den is a remarkable one. The mass which a few hours before was semi-liquid becomes quite dry and friable. It cuts almost as smoothly as cheese and is as full of holes as is well-raised bread, and for the selfsame reason, namely, the liberation of carbonic acid and other gases. The heat generated by the reaction drives off some of the moisture and most of the residue is absorbed by the gypsum which is formed. Of course the product is not yet in shape for field use but it is profoundly changed, both physically and chemically. If it has been well made, it is somewhat porous and crumbles quite readily when exposed to the air; if not, it is likely to be lumpy.

In the pile on which it is dumped it still further "cures," maintains for a long time a high temperature, dries out, its free phosphoric acid content but not its available phosphoric acid content is lessened and, in the course of a few weeks, it is ready either for shipment, after remilling to break up the lumps, as the familiar, dull gray, acid phosphate of commerce, or for use in the dry-mixing process about to be described. A Florida rock, made into acid phosphate, does not always dry out perfectly; and it sometimes happens, because of faulty manipulation, that the product is somewhat sticky. Furthermore, its free phosphoric acid contents, even after long curing, are not always reduced to a desirable minimum. Hence it is that sometimes a little finely ground limestone is mixed with the goods at their final disintegration prior to shipment, in order to put them into better condition for drilling. Acid phosphate is weakly acid and if it is not carefully made, if an excess of free phosphoric acid is present, the burlap bags in which it is shipped rot quickly. The use of carbonate of lime which neutralizes this acid tends to obviate this difficulty. Its admixture with acid phosphate tends to increase the reverted and to decrease the water soluble phosphoric acid contents, and to some extent to increase the insoluble phosphoric acid contents of the goods. If, however, the quantity used is small and the acid phosphate or base mixture has been mixed for some time, the effect may not be very serious. The argument for the use of this material is that the mechanical make-up of the goods may be bettered, that overacidity is lessened or entirely overcome, and that, perhaps, some good may be secured from the application to the soil of the extra amount of lime. At any rate, limestone is being used to some extent and apparently without serious detriment. If the stickiness which is sometimes noted is due to iron and aluminum oxids, finely ground peat or gypsum may be employed to advantage as driers.

An interesting modification of the den system was observed at one factory. The wet-mix pan is so located as to empty at will into one or the other of two or more small 30-ton dens. The fresh mixed acid phosphate, some of it not more than an hour or two old, is pushed out by hydraulic pressure upon belt conveyers, being cut perpendicularly by a succession of wires—much as tub butter is wire-cut—and carried to a large auxiliary den called in the factory parlance a "silo," in which in large quantities, perhaps hundreds of tons daily, the material "cures" for from 12 to 24 hours, whence, in fine, dry, friable condition, it is transferred by aerial carriage (see Plate VIII, figure 2) to the piles. This scheme, the so-called "Swedish" system tends markedly to lessen the dangers incident to hand removal and is said to result in an improved product.

Dens are not always used. In the South the product is quite often transferred steaming hot directly from the mixer pan by overhead automatic dump carts, directly to the open pile or dump in the storage bins. It is generally, but not universally, held that when open piles are used less rapid work can be done in the mixing pan, or else that delay must be provided for in the dump car; that as thin a product cannot be dropped on an open pile as can be run into a closed receptacle; that it must have begun to "set" before it is dumped. It is quite clear, however, that the acid phosphate cures more slowly and is not fit for shipment, either as to its available phosphoric acid content or its mechanical condition, until a much longer time has elapsed than is necessary when the den system is used. Indeed, the delay involved in the use of the open dump system is so serious sometimes that shipments of thoroughly finished products cannot be made in time for the planting season. Then, too, the dangers to animal and plant life and to the well-being of the workmen from the hydrofluoric acid fumes arising from the piles are not to be underestimated. The writer will never forget the shattering coughs of the unfortunate negro watchmen who used to patrol the car trestles over the phosphate rock bins in which the drying process was in operation at the South Carolina mines where he was employed in his early manhood; and in his mind's throat he can feel again the grip of the hydrofluoric acid gas which he experienced during his occasional excursions over the heated rock bins. However, in the warmer climates and at points remote from human habitation it is quite possible to make a first-class product at less cost by the dump than by the den system; and that is doubtless why open dumps are common in the South and now uncommon in the North.

There are about 250 plants in this country making acid phosphate, about one-half of which make their own acid whereas half of them buy it. Some concerns make acid phosphate and supply it to the dry mixing trade. Eleven of the 18 companies selling in Vermont possess acid plants—not that there are 11 plants because of the subsidiary system obtaining in the trade—, four buy acid and three are dry mixers.

THE BASE-MIX PROCESS

The higher grades of nitrogenous by-products, cottonseed meal, dried blood, tankage, meat meal, fish scrap, etc., are being used in increasingly larger quantities as food for animals. The number of animals slaughtered is lessening yearly. The supplies of the high grade organic ammoniates available for the use of the fertilizer manufacturer is becoming increasingly restricted, and their costs are mounting skyward. Hence the insistent call for the lower grades of raw materials which may be "processed," that is to say, subjected to such profound chemical change as will render their nitrogen available to the plant. This process takes place in the wet-mix pan and the den just described and the product is known as a "base-mix."

A "base-mix" or "base goods" is made by combining organic ammoniates—usually of a somewhat lower grade than standard articles such as dried blood, tankage, cottonseed meal, etc., and usually, also, of a somewhat lower availability—with ground phosphate rock and sulphuric acid in the rotary mixer, described on pages 29-30, and subjecting the product to a 24-hour sweating process in the closed receptacle or den described on pages 31-32. The crude stocks commonly employed are such as felt, fur, feathers, wool waste, leather, hair and similar mechanically inept materials, the nitrogen of which in their natural and untreated condition is relatively inert, but which where "processed" is made far more available to plant uses, particularly if the material is of animal origin. Crude stocks of vegetable origin respond less readily. Exactly the same process is employed, except that the organic nitrogenous ingredients are added at some point during the process and that the mixing process is carried on for a somewhat longer time. Sometimes these ammoniates are put into the mixer at the beginning, and at other times towards the end of the acidulating process. The addition may be delayed until the den process is in operation or, indeed, completed. Sometimes this admixture is made when the acid phosphate is removed from the den or pile and is still steaming hot, the higher grades of ammoniates then being uscd rather than the lower grades. Some-

times garbage tankage is added to the base goods while they are being transferred from the den to the pile, with a view of serving the double purpose of drying the goods and increasing the availability of the garbage nitrogen. The former purpose is always attained for garbage tankage is an excellent conditioner, but the latter is not likely to be secured. (See Plates III and IV).

The physical and the chemical characters of these crude nitrogenous materials are profoundly altered by the severe treatment they undergo in the wet-mix process, more especially by the effect of the heat generated by the action of the acid on the organic material and the ground rock and of the corrosive action of the acid as such.

The state fertilizer law (P. S. 4980), as do most such laws in States where a fertilizer control obtains, prohibits the undeclared use of "leather or its products, hair, wool waste, garbage tankage, or inert nitrogenous material" in fertilizers; yet it is a matter of common knowledge that these materials are used, the law to the contrary notwithstanding. And if used in a wet-mix it is well that they should be thus used, in moderation, for their utilization is advisable in view of the shortage of the better grades of ammoniates. Or, to rephrase the matter in another way, any process which serves to make available the otherwise unavailable tends to keep down the price of the readily available and consequently is a benefit. The identity of the leather or other forms of inhibited material is entirely lost in the rotary mixer and in the den. It is no longer leather and its presence cannot be detected. It is on account of this modern development in the process that this section of the law has become in some degree obsolete and why in the recent revision of the Vermont statutes—the "General Laws"—this section has been changed so as to prohibit the undeclared use only of "inert nitrogenous material," leaving the determination of the facts to the Station and, ultimately, to the Courts.

It should not be forgotten, however, that when used in dry mixtures the identity of these materials is not destroyed, that their availability is in no way enhanced, that their presence, if in considerable quantitites, can readily be determined, and that their undeclared usage under such circumstances is illegal.

The result of the process of making a base-mix, so far as the nitrogenous ingredients are concerned, is the more or less complete hydrolysis of the proteins, in the main resulting in the primary products of protein decomposition, that is to say, in the production of ammonia, amino acids and of some proteose-like compounds. The destructive

process goes on far enough to produce some actual ammonia which, of course, is extremely available and, likewise, a multitude of intermediate organic products, some of which appear to be directly useful as such in the nutrition of plants. The success of the operation depends largely upon the completeness of the reaction. A partly hydrolized protein is less serviceable than one which is more thoroughly broken down. In a trial made several years ago in a large fertilizer factory, supervised by the station chemist in company with representatives of other Stations, in which hair tankage, garbage tankage and unacidulated treated leather were put through the wet-mix process, the following results were obtained:

	Nitrogen as ammonia	Water-soluble organic nitrogen	Water-insoluble organic nitrogen
What went in	6.5%	7.8	85.7
What came out	14.3%	57.7	28.

The water-soluble nitrogen appeared by field, pot and laboratory tests to be as serviceable agriculturally as that derived from the better ammoniates, to be readily diffused through the soil and to become quickly available to plant uses.

THE STORAGE PILE

The acid phosphate, or the base-mix made in the manner outlined on the previous pages, stands in the pile for a greater or less length of time and cures. Its heat is still maintained, perhaps it may increase, and further reactions seem to take place. It hardens or sets more or less for the reason that the chemical process which takes place in the pan form land plaster and because of both the compaction and the contraction of the pile. In the earlier days, when manufacturing methods were less well worked out than they are now, the writer has seen piles of commercial fertilizer so thoroughly hardened by standing as to necessitate the use of small gunpowder charges to loosen them prior to shovelling. This also happens today to some extent and piles have to be "shot" down. Usually, however, mechanical diggers, or the workmen with pick and shovel, readily loosen the pile, but the material is apt to come out in lumpy form, and needs to be broken up, disintegrated, remixed, sifted and screened, whether it is to be shipped directly or is used as an ingredient of a dry mixed goods. (See Plates V, VIII, figures 2 and 4).

THE DRY MIXING PROCESS

The wet mixing process has been completed and the material, be it acid phosphate or base-mix goods, has dried out in the pile. It is now ready for the final dry mixing with forms of crude stock which cannot be used successfully in the wet-mix.

Formerly nitrate was but little used in the commercial fertilizers sold in Vermont, and the goods often were shipped directly from the dry and cured base-mix pile. They are still so shipped to some extent. The low grade, non-nitrated brands are apt to be simply the straight base-mix goods, although they are not always such. All fertilizers containing nitrates, however—and this includes two-thirds of the brands sold in Vermont in 1917—must needs be dry mixed in order to introduce the nitrate. The acid phosphate or base-mix with which the nitrate and other ingredients are commingled of course is made by the process above described (page 22). The writer has reason to believe that most of the non-nitrated brands sold this year were similarly prepared.

Dry mixing involves the thorough mechanical admixture of the several ingredients in a dry condition. This may be secured in a small way by commingling them on the floor of the storage house, using barrows for assembling and shovels and screens for mixing, just such work, except that it is done on a larger scale and doubtless in a more careful and thorough fashion, as is accomplished by the farmer who "home mixes" his chemicals upon the barn floor. Milling is advisable and quite commonly done. Nitrate of soda and some potash salts are somewhat coarse in texture and unless milled previous to mixing do not always make a mechanically perfect mixture. This system of floor mixing is still in vogue to a large extent in factories where the output is relatively small. The separate ingredients are screened when necessary, are thrown in a great conical pile, are shoveled and reshoveled back and forth, are passed through a disintegrating or milling mechanism which serves to break up the remaining clods and still further to promote accuracy and completeness of mixing and, finally, are bagged and shipped. This system is expensive in labor and plant food. It requires a maximum of human hand work per unit of crude stock and it is necessary to use a sufficient excess of plant food to insure as far as may be that even in instances of insufficient mixing there shall not fail to be an excess of each kind of plant food furnished over and above the guaranty. On these accounts and in order more effectively and rapidly to handle large tonnages, various mechanical forms of dry mixers have been constructed and put into operation.

A modern dry mixing plant crushes, pulverizes, screens and mixes the several crude stocks into a homogenous mass and weighs the resulting mixture into bags or barrels. It comprises elevators, crushers, pulverizers, screens, a rotary mixer, hoppers, chutes, spouts, conveyers, and a weighing and sacking mechanism. It is a large and somewhat elaborate affair and stands quite on a parity with the wet-mix apparatus as being a central feature of a modern fertilizer factory. The accompanying illustration of a type of mechanical mixer used in some of the factories visited by the writer will serve to make the process clear to the reader. (See Plates VI, VII, VIII, figure 3).

Let us assume that a 3-8-2 brand is to be mixed from nitrate of soda, sulphate of ammonia, $^{7}/_{15}$ tankage, 14 percent acid phosphate and sulphate of potash, carrying 3 percent ammonia (equivalent to 2.47 percent nitrogen) 8 percent available phosphoric acid and 2 percent potash, and that some inert material is used as a drier, conditioner and filler. The formula might be constructed as follows:

	Nitrogen	Available phosphoric acid	Potash
100 lbs. nitrate of soda	15	...	...
70 lbs. sulphate of ammonia	14	...	...
350 lbs. $^{7}/_{15}$ tankage	24	14	...
1,150 lbs. 14% acid phosphate.....	..	161	...
90 lbs. sulphate of potash.....	..	...	45
240 lbs. conditioner	..	...	...
2,000 lbs.	53	175	45
	2.65%	8.75%	2.25%

Now these several materials are gathered from their base piles, if at a distance, into smaller piles at convenient places on the floor adjacent to the mixer, sometimes by barrows, sometimes by scrapers, sometimes by aerial crane transmission. A scale is located at each pile, properly set and locked at the stated amount, e. g., 350 pounds tankage. A workman with a barrow is assigned to each pile whose duty it is to see to it that the correct weight of the particular ingredient he is handling is periodically dumped into the assembling hopper (1)[1]. The men work continuously and synchronously, each one assigned to one and the same duty. They follow each other with their loads at the hopper in a definite order. Workman C, for example, always dumps his load into the hopper after workman B has dumped his load and never after A or D. Thus is insured the accuracy of the mixture, that

[1]The numbers in parentheses, i. e. (1), in this and the next two paragraphs have reference to the illustration shown in Plate VI.

by no chance shall the ammonium salts, for example, be put in twice while the tankage is put in but once. A general gang boss keeps his eye on the whole procedure, and watches the scale to see that the men load on the right amounts. (See Plate V).

The ingredients which are being dumped continually into the assembly hopper (1) pass through the breaker feeder (3) (also Plate VII, figure 1). This device easily crushes the larger lumps which might otherwise clog, overstrain, or even stop the elevator, relieves the screens and pulverizes and consequently increases capacity and tends to regulate the amount of material fed to the remainder of the mechanism and to prevent alternate overwork and relative idleness. As the material passes on from the breaker feeder, it is caught and raised by the elevator buckets on an endless chain (4) to discharge through a spout or chute (5) upon a screen or separator (6) (also Plate VIII, figure 3.) There are many kinds of screens and separators in use, all designed for the same purpose, namely, to insure that the goods are so finely divided that by no chance shall they fail to "drill" well. The portion which passes the mesh drops into the mixer hopper (11); that which does not pass the mesh, the so-called "tailings" passes through a chute (7) to the "pulverizer" (8) (also Plate VII, figures 2 and 4). The implement is a busy one. It has a hard job to do and has to do it in a hurry. The coarser particles of bone, tankage and other materials which have not been made sufficiently fine by the action of the breaker (3) and the screen (6) must be handled by the disintegrator or pulverizer (8), and, if necessary, over and over again until they are thoroughly comminuted. And at the same time the fragments of iron, steel, etc., which inevitably get into a mass of this sort, must be eliminated without fail and without breaking the mechanism. And, finally, the reduction must be done quickly so that there may not be any noticeable lag lest the resulting mixture become uneven. There are several different sorts of pulverizers, the "hinged hammer," the "cage," the "flail" and others, all seeking to accomplish this difficult task. The coarser product falls quickly down a chute (9) back again to the elevator (4) and is quickly borne upward and again unto the screen (6), the finer particles to pass to the mixer hopper (11) and the coarser ones again to the pulverizer (8). If the pulverizing mechanism does not work quickly enough or does not reduce most if not all the tailings at the first impact, there is likelihood that some of the material will lag and the batch be lacking its full guaranteed composition, a shortage which is commonly found, if due to this cause, in its nitrogen con-

tent. When, finally, all is well in this respect and the mixer gate is opened, the finely divided ingredients pass from the hopper (11) to the mixer proper (13). The dry mixer is a cylindrical shaped device placed on its side and rotated rapidly on its axis. It resembles in a way the well known Simplex form of combined churn and butter worker, and yet more closely the ordinary concrete mixer. (See Plate VII, figures 5 and 6). Several wings or baffle boards are affixed to its inner periphery, which serve to throw the ingredients in a multitude of different directions during the rapid revolution of the drum and most thoroughly to commingle them. Thus there is little or no opportunity for the light and heavy ingredients to separate mechanically. The tendency of the former to "float," to remain on or to trend toward the top of the mixture is baffled or retarded. In the language of one of the trade catalogs, which the writer adopts since he cannot improve upon it, "the ingredients are forced to mix. They are thrown about, cascaded, rolled over, lifted, dropped, scooped and are subjected to so many different actions in the few seconds while confined in the mixer drum that they cannot help getting mixed."

The material thus dry mixed either may be bagged at once for shipment, as is commonly done during the rush of the shipping season, or it may be stored in huge piles during the non-shipping season. In the former case the mixed material drops through a flexible chute (14) to the second elevator (15) whence the finely comminuted material passes to the bin (16) located over the bagging scale (17) (also Plate VII, figure 3). The weighing and bagging mechanism is simply a device whereby the finished goods are filled into bags with great rapidity and accuracy as to weight. The exactness and speed with which an automatic weighing machine will shut off the flow is remarkable. The weights seem to be absolute. The bags being filled, are quickly removed, passed to a couple of workmen with mammoth needles and twine, who have all they can do in sewing the bags to keep up with the machine and, being sewed, they pass on trucks to the cars or lighters. If the goods are to be stored before shipment the mixed material drops through the chute (8) to a belt conveyer or to cars, barrows, or other conveying devices and thence to the storage bin or pile. When the time comes for the shipment of this stored material it usually has undergone more or less chemical and mechanical change. Not infrequently it hardens or "sets" more or less. Under such circumstances it is quite common to run the entire lot through the mixing mechanism a second time. More frequently, however, the goods

are simply "remilled," in which case the mixer gate is kept closed and the material having passed through the breaker (3), screen (6), and pulverizer (8), passes from the base of the mixer hopper (11) through the chute (18) to the bagging bin (16).

A commercial fertilizer is not a homogeneous substance. It is made up of a mixture of many different ingredients, of different specific gravities and textures and of particles of different sizes. It is not an easy matter to cause them to commingle thoroughly or, being mixed, to stay mixed. On this account, it is a physical impossibility for a manufacturer to guarantee that every pound of a brand will be absolutely identical with every other pound, even though the formulas are accurately calculated and the proper ingredients used in the proper amounts. Nevertheless there is but little serious difficulty in this respect. To all intents and purposes the product of a fertilizer factory as put out today is what it purports to be. Errors sometimes occur in mixing or in bagging, particularly in view of the type of labor necessarily employed in the factories and the multiplicity of brands. However, the fact that the modern American fertilizer, at any rate as sold in Vermont, is rarely poorer than it is said to be by its maker, is entirely proven by the fact that in the 20 years from 1896 to 1915, 97 percent of the fertilizers sold in the State contained the commercial equivalent of their guaranties, and in the last five of these years, 98 percent of them, and that in almost every case of shortage the deficiency was a minor one. Or, to phrase the matter another way, deficiencies in one ingredient are almost invariably made good by excesses of other ingredients.

SUBSIDIARY MECHANISMS

Among the subsidiary mechanisms used in commercial fertilizer factories may be mentioned:

1. *Aerial conveyers, electric cranes, etc.,* whereby the heavy materials are readily transported from pile to pile, from pile to mixer, from den to pile, from pile to rock mill, etc. They eliminate much hand labor, enable the workmen to build larger and better piles than otherwise would be made and multiply the output because of the increased ease and rapidity of handling. (See Plate VIII, figure 2).

2. *Mechanical wagon loaders.* Digging and loading devices on wheels run by electric motors which dig into piles of hard acid phosphate, base-mix pile, or finished goods, and elevate and deliver the material with ease and rapidity. These do the work of an army of

[1] The numbers in parenthesis, i. e. (7) in this and the preceding paragraph have reference to the illustration of the dry mixing mechanism shown in Plate VI.

shovelers and reduce the number of the wielders of the pick, provide a steady flow of fertilizer and keep the barrow men busy. (See Plate VIII, figure 4).

3. *Electric power.* The machinery of a modern commercial fertilizer plant is run by electric motors. The power can be taken anywhere, shafting is eliminated, noise is largely hushed—except at the rock mills and disintegrators—and the cost per horse power unit as compared with steam is lessened.

4. *Bags.* The cost of bags today is excessive and the supply of burlap is becoming somewhat scanty. It is not impossible that in the near future fertilizers may be shipped into Vermont as they have been shipped for many years into the Aroostook region in Maine, put up in barrels. Burlap comes mostly in bales from India. Ingenious mechanisms fold, cut, stitch, and reverse the bags which are stenciled upon a special form of printing press.

THE PROCESS IN THE SMALLER PLANTS

As was pointed out on pages 14-15, there are large numbers of small factories in the United States, making from as low as 100 to 10,000 or more tons annually. In 1914, according to the Federal Trade Commission, there were 256 wet mixing and 934 dry mixing plants, a total of 1,190. A quarter part of these plants was operated by six large companies. These commonly have subsidiary and affiliated companies engaged in the manufacture and sale of fertilizers, instead of conducting all their operations under one title. These six companies sell in Vermont, either directly or through subsidiary or affiliated companies or both; and there are three independent concerns whose goods are offered for sale within State borders. The brands appear to be made in 12 different factories. A few of these are relatively small plants making from 5,000 to 10,000 tons. The processes they employ, while in many respects similar to those in operation by the large companies, are sufficiently distinct to justify a separate statement. Two of these smaller dry mixing plants, which seem to be fairly typical of the class, were visited by the writer and carefully studied.

Dry mixers buy acid phosphate and either buy or make other ingredients. They need no rock mills, no acid plant, no wet-mix or base-mix device, no dens. Storage sheds, dry mixing devices and loading platforms constitute the entire mechanism. The smaller manufacturers often mix by hand, shovelling the materials over and over, and ship the hand-mixed, dry-mixed material bagged from the ship-

ping floor or from the storage bins. This procedure pertains only to plants which make very small outputs. In no case does any company selling in Vermont fail to use a mechanical mixer. Some manufacturers mix the ingredients in this fashion and then run the mixed material through a screening and disintegrating mechanism, a milling device, before bagging or placing in the storage sheds. Some use the ordinary horizontal rotary wet-mix pan as a dry mixer, or, in other words, use the shovel-plows of the pan in lieu of the hand work of laborers, and then put the goods through a milling mechanism. In all cases, if the goods are stored for some length of time before they are to be shipped, they are remilled, though it should be remarked that dry mixed goods made from well cured acid phosphate do not seem to be as apt to set in storage as those made from relatively freshly cured material.

As has been heretofore pointed out, a dry mixed fertilizer made in a small way may be of quite as high grade, of quite as good quality and capable of affording quite as effective service as a brand made in the large and completely equipped plant, provided its organic nitrogen is derived from approved sources.

MANUFACTURING AND SELLING COSTS

It is a common notion among farmers that fertilizer manufacturers make exorbitant profits. The Federal Trade Commission, however, reports to the contrary. It states that in 1914 of the net sales of four large companies, 67.8 percent were used in purchase of raw materials; 13.2 percent in manufacturing costs (labor, supplies, fuel, insurance, renewals, depreciation, miscellany); 6.8 percent in selling expenses (advertising, bad debts, agents' salaries and expenses, commissions, etc.): and 2.3 percent in general and administrative expenses. The total operating expenses were in excess of 90 percent. The rate of profit based on the total net investment was 6.1 percent for that year. The profit based on total net investment during the best year from 1910 to 1914 was 9.5 percent and during the poorest year 4.2 percent.

The outlay for the plant food is only one of many costs incident to the manufacture of fertilizers. The overhead charges are necessarily large. At a recent convention of the trade, its cost system committee set forth certain expense items which are here summarized in order to indicate something of the nature of the manufacturing overheads:

(a) *General manufacturing expenses,* including factory salaries, repairs and renewals, office supplies, laboratory expenses, stable and auto truck expenses.

(b) *Fixed charges,* including fire, tornado and casualty insurance and taxes.

(c) *Power plant charges,* including payroll, fuel, supplies, repairs and renewals and depreciation.

(d) *Sulphuric acid department charges.*

(e) *Acid phosphate department charges.*

(*f*) *Commercial fertilizer department charges* including payrolls, supplies, repairs and renewals, depreciations, general manufacturing expenses and fixed charges.

(g) *Loss in formulating* (3 percent) and in phosphate rock acidulation (9 percent).

(h) *Loss on bags or packages* (3 percent).

(i) *Selling expenses,* including salaries of manager, office help, salesmen, travel, commissions, advertising, postage, telegraph and telephone, interest and miscellany.

(k) *Bad debts.*

(l) *Interest* (for one year from time of purchase of materials until finished product is paid for).

A prominent southern manufacturer states that four large southern factories reckon their overhead burden to vary from $3.54 to $4.08 a ton. He states that in a Georgia factory making more than 30,000 tons annually, it costs per ton to make a fertilizer: $1.15 for salaries, $0.93 for labor, $0.80 for interest and discount, $0.33 for general expense, $0.19 for taxes, $0.13 for electric power and $0.23 for rentals, advertising, travel, telephone and telegraph, etc.

The large companies, of course, know what they are doing. They have their own systems of cost accounting. There seems reason to believe, however, that many, perhaps most, of the small operators have little or no clear understanding as to the financial end of their operations. The American Fertilizer, the trade organ, stated as much a few years ago when it said that perhaps half the output in this country is made by small manufacturers who "have very little idea of the actual cost of the materials, labor, overhead expense, selling expense, etc., that enter into the production of a ton of fertilizer."

Every careful fertilizer manufacturer, like any good business concern, takes careful thought as to original plant costs; the necessity from time to time of making mechanical changes, with respect to build-

ings, machinery and equipment, improvements in methods of operation, etc.; the changes in the values of materials, of labor and of equipment; the losses arising from the necessity of figuring overruns in the construction of formulas, so as to make sure that the goods will test as high as the minimum guaranties, as well as those caused by the evaporation of moisture and by overweight in bagging, which are usually estimated at 3 percent; the increased costs incident to doing business which in these times of stress and of rapidly advancing prices press heavily on this as on every other industry; the peculiar hardships which have overtaken the trade because of war conditions, such as lack of potash and the imminent shortage of pyrites and the depreciation which is ever present and must be faced, necessitating either constant repairs or ultimate discard and replacement or both (power, dry mixing and storage plants may last 20 years; sulphuric acid 15 and wet mixing plants, 15 years).

Do middlemen function largely in the fertilizer business? There may be several between the producers of the raw materials and the manufacturer who assembles them in the form of a mixed fertilizer; but there is only one between the factory and the farmer, namely the local dealer. Every Vermont farmer knows him. The larger manufacturers who control the bulk of the trade in Vermont have their own purchasing departments, many of them control the sources of their raw materials to a greater or less extent and dispense in the main although not entirely with middlemen's services.

REFERENCES

The following list of references is not designed to be a complete statement. It simply indicates some of the articles issued by the Federal Department of Agriculture and by a few of the Experiment Stations or printed in the trade organ, the American Fertilizer, or in its annual handbook, articles which have to do specifically with the production of raw materials or their preparation and use in fertilizer manufacture. No account whatsoever has been taken of the multitudinous publications dealing with the use of fertilizers or fertilizer constituents in crop growth or with fertilizer inspection. A list of several excellent works in the English language dealing principally with fertilizers and their usage is also given. No attempt has been made to deal with publications in languages other than the English tongue. Neither has reference been made to the trade articles, of which there are considerable numbers, published in the Journal of the Society of Chemical Industry, by the Federal Census or by the United States Geological Survey.

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JULY, 1917 BULLETIN 208

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

THIRTIETH ANNUAL REPORT

1916-1917

BURLINGTON
FREE PRESS PRINTING COMPANY
1917

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☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications concerning station matters, not to individual officers, but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

[1] Resigned February 1.
[2] From February 1.
[3] Resigned December 1.
[4] From December 1.
[5] Resigned September 1.
[6] From September 1.

ANNOUNCEMENT

The Vermont Agricultural Experiment Station is organized under an act of the General Assembly of 1886 and acts of Congress approved March 2, 1887, and March 16, 1906. Subsequent state legislation has placed upon the Station the duties pertaining to: (1) the inspection of commercial fertilizers; (2) the inspection of commercial feeding stuffs; (3) the inspection and certification of Babcock glassware and operatives; (4) the inspection of agricultural seed. Its financial support is derived from congressional funds; from state appropriations for report printing and for feeding stuffs and agricultural seed inspection; and from fees from commercial fertilizer manufacturers.

The Station is prepared:

1. To analyze fertilizers, feeding stuffs for domestic animals, seeds, milk and other dairy products, soils (for acidity only), and agricultural materials and products in general, when the results of such analyses are deemed to be of public benefit.

The Station is *not* prepared:

1. To identify fruits, grasses, weeds and other plants, fungus diseases, insect pests, etc., or to advise and assist by correspondence touching matters pertaining to agriculture, horticulture, plant or animal diseases, insect injuries, etc. The service of this character which the Station for nearly 25 years has gratuitously rendered is now performed by the Agricultural Extension Service of the College of Agriculture.

2. To identify or analyze minerals, drinking water, human food or drugs. Minerals should be sent to the State Geologist, Burlington. Waters, human foods, drugs and poison cases should be referred to the State Board of Health Laboratory, Burlington.

3. To test milk and cream regularly and in a wholesale way for any individual or company.

Instructions for taking samples of fertilizers, feedings stuffs, milks and creams, seeds, soils, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. The carriage charges on parcels sent by mail or express should be fully prepared and they should bear the address of the shipper for purposes of identification.

FINANCIAL REPORTS FOR THE FISCAL YEAR ENDING June 30, 1917

FOR THE HATCH AND ADAMS FUNDS

	Hatch	Adams
To receipts from the Treasurer of the United States, as per appropriation for fiscal year ending June 30, 1917 as per acts of Congress approved March 2, 1887, and March 16, 1906	$15,000 00	$15,000 00
By Salaries	8,597 92	8,154 11
" Labor	2,326 75	3,362 55
" Publications	117 19	.....
" Postage and stationery	338 76	64 00
" Freight and express	65 75	26 66
" Heat, light, water and power	920 84	64 12
" Chemicals and laboratory supplies	352 99	384 17
" Seeds, plants and sundry supplies	332 00	454 43
" Fertilizers	126 16	5 30
" Feeding stuffs	484 78	686 60
" Library	167 70	20 62
" Tools, machinery and appliances	140 22	35 60
" Furniture and fixtures	65 88	16 20
" Scientific apparatus and specimens	434 55	213 37
" Live stock	.....	1.008 25
" Traveling expenses	367 73	247 08
" Contingent expenses	20 00	.....
" Buildings and land	140 78	256 94
	$15,000 00	$15,000 00

FOR THE FERTILIZER CONTROL, FEEDING STUFFS INSPECTION, AGRICULTURAL SEED INSPECTION AND CREAMERY INSPECTION FUNDS

To license fees for 1917 received from fertilizer companies.		$2,985 00
To state appropriation for feeding stuffs		500 00
To state appropriation for agricultural seed inspection	$ 500 00	
To fees for agricultural seed analyses	34 50	
		$ 534 50
To balance on hand last report (creamery inspection)	$ 15 86	
To receipts from applicants for licenses	43 00	
To receipts for testing Babcock glassware	179 42	
		$ 238 28

	Fertilizer control	Feeding stuffs inspection	Agricultural seed inspection	Creamery inspection
By Salaries	$1,524 82	$ 276 48	$ 245 00	.....
" Labor	259 82	50 00	143 55	183 80
" Publications	21 75	25 42	8 50	.....
" Postage and stationery	27 92	45 88	12 17	4 00
" Freight and express	17 47	7 48	0 96	2 90
" Heat, light, water and power	58 78	2 71	.....	.....
" Chemicals and laboratory supplies.	237 07	.....	.....	.....
" Sundry supplies	2 57	14 58	4 41	11 90
" Furniture and fixtures	1 86	.....	.....	.....
" Traveling expenses.	788 59	77 45	97 56	.....
" Buildings and land.	21 60	.....	1 58	.....
Unexpended balance	22 75	.....	20 77	35 68
	$2,985 97	$ 500 00	$ 534 50	$ 238 28

REPORT OF THE DIRECTOR

JOSEPH L. HILLS

The present report covers the work of the Station during the fiscal year July 1, 1916 to June 30, 1917.

PUBLICATIONS

Nine bulletins and the current annual report aggregating about 440 pages of printed matter, have been issued during the year, the bulletins in editions of 16,000, the report in an edition of 1,000. A list of publications issued, other than the report, follows:

July.	No. 199.	Twenty-Ninth Annual Report, 1915-1916 (issued in bulletin form) by J. L. Hills—16 pages.
September.	No. 200.	Agricultural Seed: Concerning Weeds and Weed Seeds, by G. P. Burns and A. K. Peitersen—80 pages.
October.	No. 201.	Value of Different Grades of Milk in Infant Feeding, by R. M. Washburn and C. H. Jones (popular edition of Bulletin 195)—32 pages.
March.	No. 202.	Mony Meikles Mak a Muckle II—1. The Relation of the Milk-Vein System to Production, by A. W. Aldrich and J. W. Dana; 2. The Cost of Production of Milk and Butterfat in 1911 and 1912, by G. M. Nelson; 3. The Effect of the Sire on the Herd, by J. H. Wilson; 4. Concerning the Burlington Milk Supply, by J. E. Carrigan and W. T. Abell—48 pages.
March.	No. 203.	Mony Meikles Mak a Muckle III—1. The Winter Storage of Roots, by P. H. Aldrich; 2. Forcing Plants by Means of Warm Water, by W. G. Bodine; 3. Concerning Quality in Celery, by J. B. Norton; 4. The Gnarly Apple Disease of 1914, by W. H. Venable; 5. The Thermal Death Point of Yeast, by E. P. Wells; 6. Soil Sterilization, by F. O. Ockerblad, Jr.; 7. The Cost of Producing Maple Products, by C. J. Frink—24 pages.
June.	No. 204.	Commercial Feeding Stuffs, by J. L. Hills, C. H. Jones, and G. F. Anderson; Concerning Alfalfa and Soy Beans, by J. L. Hills—72 pages.
June.	No. 205.	Agricultural Seed: Concerning the Germination of Seed, by G. P. Burns, A. K. Peitersen and L. H. Flint—48 pages.
June.	No. 206.	Commercial Fertilizers, by J. L. Hills, C. H. Jones and G. F. Anderson; Concerning Barn Yard Manure, by R. T. Burdick—72 pages.
June.	No. 207.	The Manufacture of the Modern Commercial Fertilizer, by J. L. Hills—48 pages.

The more technical publications are issued in editions of small size, the more popular bulletins in larger editions. Only one set by number is issued, notice usually being given on the title page of the more popular issues of the existence and nature of technical numbers not generally distributed. The report consists of general business statements together with reprints of the bulletins of the year.

CHANGES IN THE STATION STAFF

As indicated in the list of station officers on page 2, several resignations took place during the year. A. F. Hawes, A. B., M. F., Forester, became extension service forest expert in the United States Department of Agriculture; W. C. Stone, M. S., Assistant Horticulturist, accepted a similar position at the New York (State) station; R. C. Downing, M. S., Assistant Veterinarian, entered the College of Veterinary Science of the Ohio State University; and Stanley Hargreaves, Gardener, became gardener at the New York College of Agriculture of Cornell University. Their respective places were filled by the appointment of Messrs. B. A. Chandler, B. S. (Maine), M. F. (Yale) (Acting), J. B. Norton, M. S. (Massachusetts Agricultural), H. F. Moore, A. B. (Middlebury), and Alexander Parks. L. H. Flint, M. S., was elected assistant botanist July 1.

THE USES OF THE SEVERAL STATION FUNDS

Hatch fund (Federal): "To conduct original researches or verify experiments"; the publication and distribution of the results of station work; administrative work.

Adams fund (Federal): "Only in paying the necessary expenses of conducting original research or experiments."

Neither of these funds can be used in indicating the application of research work save by bulletin publication or correspondence, but are employed simply in making the research which lies back of its application. The latter is now provided for in the Agricultural Extension Service. The Adams fund in particular is hedged about by restrictions and used strictly for research.

Fertilizer control fund (License fees for commercial fertilizers): Solely in the collection and analysis of samples of commercial fertilizers and the publication of the analytical results, together with additional information bearing upon soils, fertilizers and soil management. The unused residues revert to the state treasury and have done so for several years. They now amount to a considerable sum.

Feeding stuffs inspection fund (State appropriation, $500): Solely in the collection and analysis of samples of commercial feeding stuffs and the publication of analytical results, together with additional information bearing upon feeds and feeding.

Agricultural seed inspection fund (State appropriation, $500; fees): Solely in the collection and analysis of samples of agricultural

seed and the publication of the analytical results, together with additional information bearing upon seed and its use.

Creamery inspection fund (License fees, etc.): Solely in determining the ability of test operators and the accuracy of glassware.

Report printing fund (State appropriation, not to exceed $1,000): For printing the annual report.

HATCH AND ADAMS PROJECTS

The following Hatch fund projects have been in hand:

I, II, III, XII. Administration.

IV. Eccentric growth; tree temperature studies (Botany).

V. (1) Soil studies; (2) Work for other station departments; (3) Free analytical work in accordance with P. S. 352 (Chemistry).

VI. Forest reproduction; permanent plot work (Forestry).

VII. Hardwood factor studies (Forestry).

VIII. Quality and quantity studies with squash (Horticulture).

IX. Strawberry runner selection (Horticulture).

X. Cion selection (Horticulture).

XI. Cherry graftage (Horticulture).

XIII. Club-root of cabbage and allied plants (Plant pathology).

XIV. The effect of digestive fluids on spore viability (Plant pathology).

XV. Infectious bovine abortion (Veterinary science).

The following Adams fund projects have been in hand:

I. Forcing plants with carbon dioxid; begun in 1909. (Horticulture).

IV. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, related questions; begun in 1906. (Dairying; chemistry).

V. The effect of feeding different amounts of digestible protein to cows for a long period; begun in 1906. (Dairying; chemistry).

VI. Study of fundamental processes relative to the storage of sugars and other carbohydrates in wood and in the bark of the sugar maple, brown ash, birch, beech, oak, pine and apple; begun in 1909. (Chemistry; forestry).

VII. Maintenance rations for dairy cows, proportions of nutrients used; (a) maintenance, (b) in foetus construction, (c) in milk formation; metabolic requirements of dry cows; begun in 1906. (Dairying).

VIII. The stimulating effect of bordeaux mixture on plants, especially the potato plant; begun in 1909. (Plant pathology).

X. The potato scab; a study of immunity of the advance of the disease during the growth of tubers, etc., the relation of the effects of various chemicals, etc.; begun in 1909. (Plant pathology).

XI. The tolerance of forest trees; begun in 1911. (Botany).

XII. The damping off of seedlings due to fusariums and other organisms; begun in 1908. (Plant pathology).

XIII. Plant breeding studies with *Violoceae* and *Rubus;* begun in 1913. (Botany).

XIV. Sterility of strawberries; begun in 1914. (Horticulture).

XV. Blood complement studies; begun in 1915. (Veterinary science).

THE FREE ANALYSIS PRIVILEGE

A State law passed in 1886 requires the Station to "make analyses of all samples received (of agricultural substances and products), provided such analyses will be for the public good * * free of charge to residents of the State" (P. S. 352). At the time when this law was passed an appropriation was provided for its enforcement. When, however, in 1888 Federal funds became available for station purposes, the General Assembly of that year withdrew the appropriation but left the obligation. For many years the number of samples received for free analysis was so small that the work was not onerous; but owing to the inauguration of the parcel post system and especially to the activity of the county agents which are now located in eleven counties and are in close relation to more than 90 percent of our farmers, the volume of this work has greatly increased, being more than 300 percent larger than it was five yeas ago and probably 1,000 percent larger than it was ten years ago. During the past biennium more than 5,000 samples have been sent in for free analysis; samples of all sorts, including soils, fertilizers, feeds, seeds, dairy products and miscellaneous material. Many require but little attention, others—and their numbers are large —necessitate several hours of work apiece.

The Federal authorities protest the use of Federal funds for this work. They have always held that it was illegal to use Government money in this way, but in the days when the volume of this work was small and the outlay slight they did not make it a serious issue. Now, however, the volume is so large and the expense relatively so great, it would seem as if the time had come when the General Assembly should again appropriate a sum of money sufficient to cover the expense incurred in this line of work; otherwise it may become necessary for the Station unwillingly to take refuge behind the phraseology of the law

and to rule that this work is not for the public good. Looking at the matter in a broad way most of these analyses are made in the public interests. It is well that a farmer know what his soil needs; that he have an arbiter in the matter of creamery tests; that he may tell as to the feeds and seeds he contemplates buying. Anything which helps to make the outcome of farming operation more certain and more satisfactory in this agricultural State is in the public interest.

DEPARTMENT REPORTS

The following concise statements indicate something of the scope of the work which has been in hand during the past fiscal year:

ANIMAL HUSBANDRY

The following problems have occupied the attention of this department during the year.

1. *The feeding trials in which varying amounts of protein are being fed to dairy cows* (Adams, V) have shown striking results. A continuance of the trials is desirable in order still further to study the outcome.

2. *The maintenance requirements of dairy cows* under varying conditions both in regard to lactation and foetal development (Adams, VII) are being studied in a long term experiment. The importance of exercise as a factor in maintenance requirements was strikingly shown during the year.

3. *The metabolic requirements of dry cows* (Adams, VII) which alternately gain and lose weight between wide limits have been further studied. Individuality plays an important part in this trial, hence it is desirable that a considerable number of records be secured in order to minimize the effect of the personal equation.

4. *The nutritive values of milks of varying composition for infant feeding* (Adams, IV) a trial which has already borne fruit in the form of two publications—Nos. 195 and 201—has been vigorously pursued during the year using young pigs as laboratory animals and will be continued for some time to come.

ADVANCED REGISTRY

During the past year 88 Vermont breeders have secured advanced registry records. Although there are fewer breeders in the State doing advanced registry work, there was an increase in the number of tests run.

The following statement sets forth the work done from July, 1916, to July, 1917.

Ayrshire—Eight breeders have had 128 cows on semi-official yearly tests, with a total of 702 tests for 1,404 days.

Guernsey—Five breeders have had 42 cows on semi-official tests, with a total of 209 tests for 421 days.

Holstein-Friesian—Fifty-three breeders have had 182 cows tested for 1,280 days.

Jersey—Twenty-two breeders have had 313 cows on test for a total of 1,729 tests for 3,677 days.

Total of 88 breeders, 665 cows, 2,825 tests, 6,782 days.

The smaller number of cows on test as compared with last year is undoubtedly due to the high cost of feed during the year. A considerable number of the breeders who had made arrangements for tests cancelled them because they were unable to secure the necessary feed.

The location of the advanced registry work about the State has changed somewhat during the past year. The five leading counties with the number of cows tested in each county, are as follows: Windsor 117, Franklin 114, Orleans 83, Rutland 72, Windham 71.

RECEIPTS

Cash on hand July 1, 1916	$ 272	41
Official test fees	4,884	39
	$5,156	80

DISBURSEMENTS

Salaries	$ 619	90
Labor	3,451	00
Postage, stationery, telephone and telegraph	116	85
Freight and express	11	48
Chemicals and laboratory supplies	41	86
Sundry supplies	20	40
Furniture and fixtures	28	45
Travel (supervisors)	501	51
Travel (official)	32	56
	$4,824	01

ASSETS

Receipts (as stated above)	$5,156	80
Due from breeders	264	18
	$5,420	98

LIABILITIES

Disbursements (as stated above)	$4,824	01
Due supervisors	218	77
	$5,042	78
Cash on hand June 30, 1917	$ 332	79
Excess amount due from breeders over amount due supervisors	45	41
	$ 378	20

BOTANY

1. *Tolerance of forest trees* (Adams, XI). This study has been continued chiefly along the same lines as those of the previous year. The experimental evidence thus far secured seems to indicate that tolerance of forest trees is a result of the combined action of many factors and that light is not necessarily the most important. An analysis of these other factors has been begun by comparing the physical conditions in the various experimental habitats used. The new experiments started this spring are intended to afford additional evidence touching the effect of some of the various factors composing the weather on the development of forest seedlings.

2. *Eccentric growth* (Hatch, IV). The study of the cross-sections of the trees grown under experimental conditions in the field and in the greenhouse has been under way during the winter. Mechanical tests carried on in the engineering laboratory on the wood of eccentric trees have shown that the two sides differ greatly in tensile and compression strengths. Some of the trials of the past year are being repeated this summer.

3. *Forest reproduction* (Hatch, VI). Accurate records of all changes in the vegetation of the sample and control plots previously described have been made. These records include both a quantitative and qualitative analysis of the vegetation and seek so far as possible to find the causal factors in the plant successions noted. This work has been carried on in cooperation with the forester.

4. *The storage of starch* (Adams, VI). The work of the past year, so far as the department of botany is concerned, has consisted entirely in gathering additional material for future study.

5. *Plant breeding* (Adams, XIII). The study of sterility among the Vermont forms of blackberries has been continued during the present year. Cytological studies have been carried on in an attempt to ascertain the nature of this sterility. The flower development of several species and hybrids have been compared. The segregation of Mendelian characters is also being studied in both the seedlings from artificial croses and from natural hybrids.

CHEMISTRY

The work for the past year is covered in a general way by the analyses of licensed commercial fertilizers (bulletin 206); of commercial feeding stuffs (bulletin 204); analytical work connected with the feeding trials with dairy cows, including roughages, concentrates and

milk; and with more than 1,600 miscellaneous analyses of agricultural materials sent in by residents of the State (Hatch, V, 3).

1. *Feeding values of milks of different grades for infant feeding* (Adams, IV). This project has been vigorously pushed during the past year. The "pig house" has been repaired and equipped with heating apparatus and trials are now to run during the winter months as well as during the summer.

The work attempted is a continuation of that published in Bulletin 195, along somewhat different lines, use being made of artificial milk mixtures made from skimmilk powder, milk sugar, dextrin-maltose and unsalted butter. As a rule the fat percentage has been held low, 3% or under, and the protein content of the mixtures varied.

Five litters of eight pigs each have been fed and slaughtered. The analytical work has been completed on the first three litters. Relatively poor utilization of milk sugar and fat, and very good utilization of protein were secured. All the animals were at all times in vigorous health and free from digestive disturbances.

2. *Soil studies* (Hatch, V, 1). Some 350 samples of soil have been examined for lime requirement and about 50 samples of limestone have been tested. Such evidence as has been secured indicates that beneficial results follow the application of lime when alfalfa and clover are grown. Much of the limestone submitted has been found to be of the dolomitic type containing magnesium carbonate associated with the lime.

3. *Quality and quantity studies with squash* (Hatch, V, 2; VIII). Partial analyses of about 100 samples of squash have been made for the department of horticulture with a view of determining the relation of variations in their chemical contents to quality factors.

4. *The carbohydrate contents of maple wood* (Adams, VI) has been studied as in previous years. The results secured have been tabulated and necessary repeat determinations made preliminary to the preparation of a manuscript.

A total of 3,298 samples has been analyzed.

Milk (station herd) (Adams, V)	306
Milk and cream (from private individuals) (Hatch, V, 3)	895
Commercial fertilizers (official)	171
Commercial feeding stuffs (official)	611
Roughages and concentrates (in connection with protein trials) (Adams, V)	464
Wood (carbohydrate storage problem) (Adams, VI)	50

Miscellaneous (from private individuals) including soils (Hatch, V, 1, 3)	699
Miscellaneous (horticultural department) (Hatch, V, 2)	102
	3,298

INSPECTION WORK

1. *Commercial fertilizers.* Fertilizer control work continues to be an important and popular phase of station endeavor. The writing, printing and distribution of the results of the yearly inspection as well as of the compiled matter dealing with sundry phases of soil management is paid for with fertilizer control funds. In no way whatsoever, directly or indirectly, are the Federal funds used for this purpose. One hundred and seventy-one brands, the output of 18 companies, were analyzed and, with some rather notable exceptions, were found to be as good as they were said to be.

2. *Commercial feeding stuffs.* The small appropriation for this work, less than that made in any other State, necessitates an inadequate control of this trade. More than 600 samples have been drawn and analyzed for protein only. The outcome was a very unsatisfactory one, a large number of feeds being seriously deficient. The Station is able to purvey much general information in its feeding stuff bulletins.

3. *Creamery glassware and operators.* The usual number of cream and milk bottles have been examined as to their accuracy. The percentage of imperfect and incorrectly graduated bottles found has been very small. An occasional failure to pass the operator's examination occurs and licenses are refused.

4. *Agricultural seed.* More than 350 samples were collected in 1917. These have been tested, the results appearing in bulletin 205. Guaranties were omitted on one-twelfth of the sales; were not made good in fact in about 2 percent of the samples; and 18 lots of timothy and redtop were found to be ergotized or to contain Russian thistle or corn cockle.

FORESTRY

The two lines of work outlined in last year's report have been continued.

1. *The permanent sample plot work* (Hatch, VI) has been conducted in cooperation with the department of botany and in the main involves for the present the maintenance of the botanical records by

visitation and minute inspection on the five sample plots in Plainfield, West Rutland, Proctorsville, Townshend and Burlington.

2. *The hardwood factor study* (Hatch, VII) has been pushed as rapidly as possible. Many trees were measured during the fall and the total is now in excess of 1,200. The volumes of these trees were carefully computed during the winter and spring, the relationships between the different factors influencing volume are now being studied, and the data and findings are being prepared for publication.

HORTICULTURE

The work of the horticultural department for the past year has been devoted to the following projects:

1. *Forcing plants with carbon dioxid* (Adams, I). A further study has been made of optimum applications, and, with the determination on this point, the experiments were discontinued. Much time has been given to the preparation of the manuscript which is nearly ready for the printer.

2. *Sterility of strawberries* (Adams, XIV). A large number of the first generation of crosses has been pollinated, and many thousands of seedlings raised in order to note the sex of offspring resulting from a crossing of perfect and imperfect varieties. Many varieties have been self-pollinated for the purpose of determining the stability of certain types of sexuality.

3. *Cion selection* (Hatch, X). Data are being collected from year to year as to the capabilities of cions of supposedly high or low productive powers. As yet but little information is on hand which will warrant a forecast of results. Data as to bloom, set and yield of fruit, on growth and amount of prunings on both sets of cions, are being gathered from year to year.

4. *Quality and quantity in Hubbard squash* (Hatch, VIII). The study of quality and quantity of squash has been continued along practically the same lines as in previous years. Some attention has been given to possible correlation in edible quality and chemical composition, also to the quality of the same strain at different storage periods. As originally planned this project is nearing completion and will doubtless be reported upon in the not distant future.

5. *Strawberry runner selection* (Hatch, IX). Owing to the pressure of work in connection with other projects, but little progress has been made on this experiment during the past year. However, an-

other generation of plants has been raised which will be due to fruit in 1918.

6. *Cherry graftage* (Hatch, XI). This experiment has for its goal the determination of the interrelation between stock and cion among different species of cherry. A large number of seedlings has been raised as foundation stock for breeding and graftage experiments. The progress of the work has been delayed by the difficulty of securing species from foreign countries, but considerable advance has been made.

7. *Influence of self pollination on the quality of fruit and vitality of offspring* (Adams, XVI). The Hubbard squash and the strawberry have been selected for his experiment. Self pollination work has been started using certain advanced forms from the sterility and the squash project experiments above referred to as foundation stock.

PLANT PATHOLOGY

The plant pathology projects of the year have been as follows:

1. *Potato scab* (Adams, X). In addition to a continuation of the observations on resistant and susceptible varieties and the structure of their skins, considerable time was spent in studying the effects of fertilizers and soil disinfectants on the thickness of the skin of several varieties. No definite conclusion has as yet been reached regarding this point and the work is being continued.

2. *Effect of bordeaux on sprayed plants* (Adams, VIII). To the control of the potato disease known as "tip-burn" may be largely ascribed the favorable results obtained from spraying with the copper mixtures. This project has developed into a study of this disease and its prevention by bordeaux. Several other plants have shown appearances similar to those of the potato affected by this trouble. Shading with or without spraying has been tried. Attempts have been made to ascertain the nature of the changes which occur in the chlorophyll during the progress of this disease for the reason that in many cases chlorophyll destruction seems to bear causal relationship to the malady.

3. *The fusarium wilt of peas and asters* (Adams, XII). No experimental work was undertaken on this project.

4. *Club-root of cabbages and allied plants* (Hatch, XIII). No experimental work was conducted further than to test for resistance to club-root a strain of cabbage found by the Wisconsin station to be especially resistant to cabbage wilt, comparisons being made with several standard varieties.

5. *Digestion of fungi spores by animals* (Hatch, XIV). Smut material was collected during the summer of 1916 and fed to various animals during the winter of 1916-17. The manure has been used for field trials. Laboratory experiments are being conducted at the same time on the viability of spores imbedded in manure or in the soil.

VETERINARY SCIENCE

The efforts of the department during the past year have been directed to the furtherance of the following projects:

1. *The treatment of infectious abortion* (Hatch, XV). The complement fixation test was employed in all available herds in which the disease obtained in a satisfactory stage for experimental treatment. The methylene blue-cresol treatment was not resumed on account of the continued scarcity and prohibitive high price of the methylene blue, but another cresol combination was used on about 100 additional reacting cows. This preparation possesses some distinct advantages over that containing the methylene blue and the results obtained with it seem to warrant more extensive trials.

2. *Control of blood complement* (Adams, XV). Progress on this project was seriously interrupted twice during the year by the loss of several hundred of the breeding guinea pigs. During July and August over 700 died from hemorrhagic septicemia and as many more were lost in March as a result of not getting a sufficient amount of roots or other similar food. The deficiency was finally met by supplementing their dry food with a liberal supply of skimmilk, since which modification in their diet almost no deaths have occurred.

One thousand and fifty-two additional animals were produced during the year, the blood of which was carefully studied with reference to complement.

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

THE COST OF PRODUCING MARKET MILK IN 1916-17 ON 212 VERMONT FARMS

by G. F. E. STORY and W. J. TUBBS

THE VERMONT AGRICULTURAL EXTENSION SERVICE

THOS. BRADLEE, Director

AND UNITED STATES DEPARTMENT OF AGRICULTURE, STATES RELATIONS SERVICE, COOPERATING.

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☞ Address all communications concerning station matters not to individual officers but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

THE COST OF PRODUCING MARKET MILK IN 1916-17 ON 212 VERMONT FARMS

By G. F. E. Story and W. J. Tubbs

SUMMARY

1. Records were taken on 212 farms representing 4,650 cows distributed throughout Vermont.

2. The average cost of making milk during the year May 1, 1916-April 30, 1917 on these farms was $136.11 per cow, the net cost $111.86; the average production was 2,478 quarts or 5,328 pounds per cow; and the average cost per quart at the farm 4.51 cents and per 100 pounds $2.23.

3. It is the judgment of the writers, formed after careful study of these data and of the present trend of prices for feed, roughage, labor, etc., that at the present writing, Oct. 1, 1917, the average cost of making milk on the farms under survey last spring, if one allows as should be allowed a reasonable return for the farmer's labors, approximates $165 per cow, the net cost about $147 per cow, and the average cost per quart and per 100 pounds at the farm in the vicinity of 5.9 cents and $2.75 respectively.

4. Farmers who fed silage made milk at nine percent less cost than did those who fed an all-dry ration; and those who bought their grain at the time when its price was relatively low saved money as compared with those who bought piecemeal.

5. The use of scrub bulls is costing the farmers of Vermont thousands of dollars annually. A good pure bred sire should be available to every Vermont dairy farm.

6. An excellent means of reducing grain requirements is to grow soy beans in the silage corn and to increase clover and alfalfa areas.

7. The amount of man labor per cow is excessive on many farms. This is due to small herds, frequent feedings and to ill-planned barns. A litter carrier pays for itself in a year at present labor prices.

INTRODUCTION

The Committee on Agriculture of the Boston Chamber of Commerce, cooperating with the Agricultural Colleges in the several New England States caused a survey to be made in the months of May and June, 1917, of the cost of milk production during the preceding year. While the initiative was taken by the Committee the entire expense of the Vermont survey was borne by the University through its Agricultural Extension Service, the cooperation being mainly one of good will. This is said in no sense in a captious spirit, but simply by way of explanation.

No argument is needed to prove that in a critical time like the the present, with advancing prices and changing values, with sharp differences of opinions as to actual production costs, with none too much valid data at hand as to such costs, it is eminently desirable that the actual expense involved in the production of a quart of milk under present day conditions on a Vermont dairy farm shall be determined.

Nelson made such a survey in a small way in 1911-12. The results have just been issued in condensed form as one among many articles in Bulletin 202, pages 25-39 (1917). The recent distribution of this article, dealing with the situation as it existed five years ago when it cost infinitely less to produce milk than it does today, makes it particularly necessary to issue this statement bringing the matter more nearly up to date; otherwise misunderstanding is likely to arise. It is believed that the present bulletin sets forth with a fair degree of accuracy the facts as to the cost of producing milk in Vermont during the twelve months preceding May 1, 1917.

Definite knowledge as to the legitimate charges which enter into the cost of production, handling and marketing is an absolute essential to success and permanency in business. Some of these may be overlooked for a time, as, for example, depreciation. The operator may shut his eyes to them, but the day of judgment awaits him. Many a seemingly sound enterprise has been wrecked because of failure to take all the expense items into account. Accurate systems of cost accounting in business enterprises are now required by law in several States, in order to protect the interests of investors. Of course, in the restricted sense, the individual dairyman does not have to protect any one but himself, yet in his own interests he ought to know what it costs him to do business. Dairymen find it hard to keep accurate cost accounts owing to the complex nature of their business and to the many and diverse lines of work in which they engage. This makes it

all the more necessary that a survey be made as a basis from which the individual can make an estimate in his own case.

The rapidly rising costs of labor, feed, livestock, etc., have forced New England dairymen to demand higher prices for market milk than consumers are willing to pay unless the cost of producing milk is clearly understood. Definite production cost data must be shown in justification of price demands. These figures are not easily secured because few farmers keep accounts with their different farm enterprises and costs are constantly changing. However, acting on the initiative of the Committee on Agriculture of the Boston Chamber of Commerce, the Agricultural Extension Service of the College of Agriculture of the University of Vermont sent men into the field in May and June last, who, as a result of personal consultation with and questioning of 212 representative practical farmers, secured first hand and reasonably accurate data as to the cost of milk production in Vermont from May 1, 1916 to April 30, 1917.

The working crews were composed of University instructors and seniors and juniors in the College of Agriculture, all of whom had received instruction in the principles of farm management.

(a) W. J. Tubbs, Farm Management Demonstrator (in charge), F. R. Churchill, '17, E. M. Root, '17, R. A. Briggs, '18.

(b) R. T. Burdick, Professor of Agronomy (in charge), H. A. D. Leggett, Instructor in Poultry Husbandry, F. B. Jenks, Professor of Agricultural Education, A. C. Lewis, '17.

(c) G. F. E. Story, Professor of Animal and Dairy Husbandry, (in charge), H. V. Adams, '18, J. A. Hitchcock, '18.

No attempt was made to "hand pick" these 212 farmers. They were meant to represent as nearly as possible the average of good dairymen. The advice of the county agents was sought in their choice. As a whole they probably were a little better than the average, yet not sufficiently so to cast doubt on the validity of the results, which represent what careful, moderately well informed and thoughtful breeders and feeders are accomplishing. The number of cows in these 212 herds was 4,650.

The following table indicates the distribution of cooperators who were located in 12 of the 14 counties of the State:

County		Number of records
Addison,	4 towns	21
Bennington,	5 "	14
Caledonia,	6 "	20
Chittenden,	5 "	18

Franklin,	4 towns	22
Lamoille,	4 "	20
Orange,	5 "	15
Orleans,	6 "	15
Rutland,	4 "	17
Washington,	6 "	17
Windham,	7 "	19
Windsor,	6 "	14
Total		212

About one-third of the 212 dairymen were shippers of market cream. It is not easy to find market milk shippers in some sections of Vermont. However, these men are potential milk shippers and no sound reason can be advanced against the inclusion of the data thus secured which has been calculated and expressed on a whole milk basis.

DEBITS

An important step in cost accounting is the establishment of an accurate inventory at the beginning and at the end of each year. The inventories used in this study were so arranged as to show the total *cow cost* for the year.

The following items have been considered in determining the cost of milk production, all being reduced to the unit basis of the single cow: (1) Cow, (2) sire, (3) food, (4) labor, (5) plant (buildings), (6) equipment, (7) bedding, (8) miscellaneous charges, (9) allowance for managerial ability, business risks, etc.

1. cow

In arriving at the average figure to apply to the average cow, interest at 6 percent was figured on the average valuation of the herd, sales being balanced against purchases. Heifers were not considered to be a part of the herd unless they had freshened.

Owing to the sharp increase in the value of dairy stock during the past year, an *appreciation* occurred instead of a depreciation. This amounted to $7.28 per head, equivalent to 10.3 percent gain. While this abnormal result is apparent in the survey for the current year, it will not hold true over a period of years. The only reasonable course to pursue in figuring future costs is to charge a normal annual depreciation on the present value of the herd. After careful study it was decided that 12 percent represented a fair depreciation charge to be used

in computing future costs and consequently an item reading "depreciation on cows, 12 percent on $77.41 = $9.29" appears in the estimates on page 17. Where a cattle owner sells his cows as soon as they reach their maximum values and replaces them with heifers at a lower price, 12 percent is perhaps an excessive figure, but under average herd conditions and in normal times it is not far from correct. For the purposes of this survey, the 4,650 cows were valued at grade prices, whether registered or not, for the reason that it did not seem fair to charge the heavy investment of a breeding establishment against the production of milk. It may be remarked, however, that many of the pure-bred cows paid a high return on their actual values.

2. SIRE

Many items, such, for example, as interest on investment, depreciation, feed, labor, bedding, etc., enter into the cost of maintaining a herd sire. From the total expense should be subtracted the service fees received from outside sources in order to arrive at the net cost to the herd of sire maintenance. The cost per cow was found to be $1.94. This is a very low figure for registered sires. It would not be possible, except in large herds, were it not for the common practice of using young grade bulls and, later, selling them for beef, the gain in weight often covering the cost of feed and depreciation. There is little to recommend and much to condemn in this practice.

A prepotent pure-bred bull from producing ancestry will add easily ten dollars' value to the appearance and productivity of his daughters. If the bull cost $500 and no more than five heifers are retained in the herd yearly, the investment has paid 10 percent interest. Many splendid young sires as well as some proven animals can be obtained at reasonable prices. There is no excuse nowadays for the use of an inferior sire.

When dairymen realize more clearly than at present the value of uniform stock, and when animal diseases are better controlled than they are today, closer cooperation may be looked for among cattle men along the line of the establishment of local breeders' organizations. Many cattle owners now feel that a dollar is the limit for a service fee, and even at that low figure often are so heedless that they bring diseased cows for service. It is safe to say that it costs many owners five dollars per cow for service, especially in small herds.

3. FOOD

The average cost of the hay fed at the barn was $11.94 per ton, and, since most of it was mixed hay, this figure may be held to represent a fair farm value. The average cow consumed 3,500 pounds, costing $20.93. Silage was figured at $4.39 a ton, which would be a low estimate for the immediate future, owing to the increased labor costs of the present season. An average of 5,440 pounds, costing $11.93, were fed per cow. Green soiling crops were valued at $4 per ton and represent an outlay of only 80 cents in the total feed cost per cow. A small amount of dry forage was fed in some cases equivalent to 51 cents per cow.

Grain to the extent of 1,240 pounds, costing $25.48 per cow, was fed. The average price of grain was reported as $41.12 per ton. Grain charges during the past year were extremely dissimilar on the various farms studied in this survey, owing to the fact that some of the dairymen were forced to purchase more or less of their grain on the high winter market, having bought insufficient supplies during the fall.

The pasturage costs totaled $6.95 per head. This figure was secured by combining interest charges and taxes on the land used, with the fencing and other expenses.

The average total food cost was $66.60 per cow, with which should be included as a proper item the interest charges on the feed inventory, which in the present instance amounted to $0.86.

Several factors entering into the food cost caused wide variations in individual cases. Among the more important are:

(a) *Value of land used for pasturage.* In Addison county, smooth meadow land worth from $75 to $100 an acre often is used as pasture and its cost is naturally very high. In other sections pasture valuations are low for the reason that there is little or nothing growing which the cattle will eat and the areas are nearly worthless from a pasture standpoint. It is to be expected that intensive feeding under either of these conditions ought to yield a greater profit than does straight pasturage.

(b) *The silo influences feed costs.* Approximately four-fifths of the farmers whose records were studied owned silos and one-fifth did not. It cost a half cent more per quart to produce milk when hay was used as the sole roughage than it did when both hay and silage were fed. Every Vermont farm carrying eight or more cows should have a silo. If one is milking less than eight cows and is not likely to in-

crease the numbers of the herd, probably it will be more profitable to raise mangels or half-sugar beets as a succulent feed than to construct a silo. Few people, other than the breeders who are doing official record work, realize the value of beets as a milk producer. It is safe to say that not one cow in ten making a large advanced registry record does it unless beets form an important part of the roughage ration.

(c) *Soiling crops are not commonly grown* in Vermont, since summer silage is usually cheaper and more satisfactory.

(d) *The scarcity of commercial feeds* during the past winter should teach Vermont dairymen the desirability of raising their feed at home whenever practicable, of growing soiling crops and of feeding silage the year around. Many of them raise little or no grain at home for cattle feeding and grow only a poor grade of roughage. Much effort was put forth this year throughout the State by the Agricultural Extension Service and especially through the county agents to secure the growing of an increased acreage of clover, alfalfa, soy beans and small grains. Farmers who adopted these suggestions and are planning to a greater extent than hitherto to feed their cattle on their home-grown resources, should be able to satisfy their needs at less cost and with equal or greater effectiveness than their neighbors who resort to the feed store. Furthermore, the railroads, now overburdened with the task of moving war freight, will be relieved of hauling much Western and Southern grain. This in itself is a patriotic duty.

Lest the reader misunderstand, it should be said that the purchase of grain for dairy cattle feeding is proper in normal times provided reasonable prices are charged, if it is used not in lieu of but as a supplement to home-grown material. Under such circumstances the practice is economically defensible, provided a new dollar can be seen clearly on its way to replace the old one laid out in grain purchase. The writers always and consistently have advocated the well-advised purchase of grain for dairy cattle and expect to continue such advocacy when the times are not out of joint. However, in view of the extremely abnormal conditions now obtaining and the high prices of all kinds of grain in comparison to the value of the product, they stress more than ever the necessity of reliance upon home resources and emphasize the imperative need that the farmer who purchases grain for his dairy cattle make wise choices. The poultrymen have been most persistent buyers of feed, but present conditions are forcing them upon a self-supporting basis. Surely Vermont dairymen will not allow

themselves to be outdone by their poultry keeping friends in the economical feeding of their stock.

Never was it more essential that dairymen study the markets in order to get what their herds really require; never was it more necessary that they have a clear understanding as to feeding values. Cattle now are being fed more and more on the several by-product feeds, some of which are well worth while and some of which are well worth leaving alone. Many farmers give little thought to the actual food value of the materials they buy. This seems to be especially true in these days of high prices when the cost per ton governs the selection of feeds. The Vermont law requires that a clear statement of the ingredients used in the make-up of a compound feeding stuff shall appear on the bag as well as a statement of its contents of protein, fat and fiber. Any farmer who reads the ingredients' statement can form a fairly shrewd notion as to the nature of the goods. For example, a brand of feeding stuffs largely sold in Vermont bears upon each bag the following statement: "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Any well informed dairyman can see that all these ingredients are high-grade and standard materials, well adapted to milk making. Another feed offered for sale in the State declares on each bag that it contains: "Ground oats, corn feed meal, wheat middlings, oat middlings, oat hulls, clipped oat by-products, ground grain screenings, 0.75% salt." Comment is unnecessary. Surely the second statement compares but poorly with the first. It is hardly to be expected that a man with his eyes open, a man knowing anything whatsoever about economical stock feeding, would buy the latter goods for his dairy cattle except at a relatively low figure. The Experiment Station's annual feeding stuffs bulletin clearly sets forth the manufacturers' statements as to ingredients and the protein, fat and fiber contents of each feed sold in the State. It is free for the asking. Its careful study ought to prove profitable to feed buyers. Dairymen who are in doubt as to what to feed should counsel with their county agents.

4. LABOR

It has been assumed sometimes that the monetary value of the calf and the manure might be considered equivalent to the outlay made for the labor involved in caring for the herd. Such an assumption surely is not valid under present conditions, and obviously a study of the labor charges on these 212 farms was an imperative necessity.

Man labor. Careful estimates were secured of the time actually spent in milking, caring for the herd, hauling the feed, etc. The price per hour stated in each case by the individual farmer was that which was ruling in his locality. The average was 21.9 cents per hour and this sum was applied in the calculation of all labor charges whether performed by hired men or by members of the family. The present conditions of the labor market are such that 25 cents certainly is a conservative figure for use in computing future labor costs. It took 158 hours to care for a cow during a year, which, at 21.9 cents per hour, amounted to $34.53.

Wide differences were noted in the labor costs on various farms. Some of the reasons for these divergences were:

(a) *Inconvenient barns.* Many of the barns were old, out of repair and ill adapted to the purpose of making milk; yet it would not be found a difficult task to rearrange many of them at comparatively slight outlay, so that much labor would be saved. Oftentimes the expense of such changes would have been thoroughly justified as an investment. Especially is it often worth while to install a litter carrier which generally will pay for itself within a year.

(b) *Small herds.* There are many duties or chores which take almost as long a time to accomplish in a small herd as in a large one. This, of course, handicaps the small farmer.

(c) *Excessive care.* Every good farmer likes to see his cattle look well, but there is a limit beyond which it is not profitable to spend labor on cows. This limit seems to be not far from 175 hours per year.

(d) *Long hauls.* Those farmers are disadvantaged whose barns are located at a distance from the feed store or are too small for their business, necessitating the hauling of hay from stacks or from outlying barns.

Horse labor. This was figured at 14.1 cents per hour. It is not a large item for the reason that only eight hours of horse labor were required for the average cow, costing $1.09. It seems safe to assume that future costs should be based on an 18-cents per hour charge, owing to the present advanced cost of maintaining a team. The milk haulage charge is not considered in this connection, being discussed under production. This fact accounts for the small amount of horse labor charged against the individual cow.

The total labor cost was found to be $35.62 per cow.

5. PLANT

A depreciation charge varying in most cases from two to four percent was charged against that portion of the buildings used or maintained for the purposes of the milking herd. Interest, insurance and repairs were also computed in order to determine the total building or housing costs properly chargeable against the herd. The cost of this item was $7.50 per cow.

6. EQUIPMENT

This item included such articles as pails, strainers, forks, milking machine, if used, but not the separator. The cost of this item was $1.12 per cow. In this connection it may not be amiss to remark that dairymen should see to it when establishing a herd that the cost of buildings and equipment is kept at as low a point as may be consistent with the maintenance of the cows in a comfortable and healthful condition. In some instances observed in the present survey the use of relatively expensive buildings and equipment more than doubled the charges necessarily debited against the cows for housing and equipment.

Where a milking machine was not used the equipment cost was in the neighborhood of 50 cents per cow.

7. BEDDING

The bedding was charged at the price which was paid for it, if purchased, whereas whenever it was home-grown a fair price was assessed. It cost on the average $1.69 annually to bed a cow. Straw cost much more than did either shavings or sawdust.

8. MISCELLANEOUS CHARGES

A number of small items are grouped under this head for convenience sake, all of which are legitimate costs although, owing to local conditions, all do not pertain to every farm. They include:

(a) Insurance on cows, based on the rate paid in each instance, usually 0.4 percent on two-thirds of the value of the herd.

(b) Veterinarian's fees, medicines, disinfectants, etc.

(c) Feed grinding.

(d) Ice (in many cases a cold spring was available which made the use of ice unnecessary).

(e) Cow testing association dues and fees. This item seems as legitimate a cost as the bookkeeping expense of a business house, and indicates that the farmer is desirous of maintaining an efficient herd.

The cost was $1.25 per cow annually. Not all the farmers represented in this survey were members.

(f) Salt, stockfoods, etc.

(g) Taxes on cows, based on the local tax rate and figured on two-thirds value of the herd.

(h) Water and light, if purchased, at meter rates.

These items amounted to $3.97 per cow and do not include milk hauling for the reason that a barn cost and not the cost of the product delivered at the railroad station was sought in this survey.

9. MANAGERIAL ABILITY, BUSINESS RISKS, ETC.

The farmer who successfully conducts a dairy enterprise is justly entitled to something more than the regular wage of 21.9 cents per hour. Otherwise the "boss" stands on a level with the "hired man." He who directs and oversees is on a par with him who is told what to do. He is entitled to a fair profit on his business, to an income above bare cost charges in view of business risks such as temporary loss of market due to strikes, etc., to a sum which shall cover all sorts of minor incidental charges, such, for example, as telephone, postage and stationery and sundry small supplies. The farm management experts of the Federal Department of Agriculture have very thoroughly studied this phase of the matter and state that 10 percent of the total costs of conducting the business is a reasonable charge. The total in this survey was found to be $123.74 and consequently $12.37 is allowed as a proper charge under this item.

The total average expense per cow on the 212 farms in this survey may be stated at $136.11.

CREDITS

The following items have been deemed proper credits, all being reduced to the unit-basis of the single cow: (1) Increase in stock value, (2) manure, (3) calf, (4) hides and feed bags, (5) production.

1. INCREASE IN STOCK VALUE

The increase in value of the stock during year 1916-17 amounted to $7.28 per cow or 10.3 percent of the individual value. This, of course, is an abnormal outcome. Under normal conditions this appreciation charge would be replaced by a depreciation charge of approximately 12 percent as noted above.

2. MANURE

It was assumed in this study that the average cow would void at the rate of a ton per month for the time she was in the barn. Each farmer was asked to name the price he considered a ton of manure to be worth. On this basis $12.96 was the credit given for the manure per cow per year. This figure corresponds closely with that determined as a result of careful estimates made by experts in other States.

3. CALF

The value of the calf was figured on a grade basis when the calf was three days old and averaged $3.52. The actual value of a calf at present veal prices is at least $5.00 and this figure has been used in estimating future credits.

4. HIDES AND BAGS

Hides from cows lost to the milking herd, and cow feed bags averaged $0.49 per cow.

These four credit items totaled $24.25, leaving a net cost of $111.86 to be defrayed by the returns received from the sale of milk.

5. PRODUCTION

As a result of the careful study of cow test association records when these were available as well as of the returns from milk and cream sales, giving due weight to conservative estimates as to household and other uses in each of the 212 herds, it was determined that the 4,650 cows produced on the average 2,478 quarts or 5,328 pounds of milk, including that used in the home, furnished to the hired help, and fed to the calves. The cost per quart on this basis at the farm was 4.51 cents. The cost of hauling milk to the shipping station varied from 10 to 25 cents per one hundred pounds. In case the farmer delivered his own milk, an allowance for man and horse labor at regular rates was charged. The haulage cost per quart averaged 0.273 cents, or a trifle less than one-third of a cent per quart.

A tabular summary of the previous discussion follows:

SUMMARY OF COST OF MILK PRODUCTION, MAY 1, 1916-APRIL 30, 1917 ON 212 VERMONT FARMS LOCATED IN 12 COUNTIES

4,650 COWS. 5,328 LBS. (2,478 QTS.) MILK PER COW

AVERAGE COST PER COW

FOOD COST

Grain	1,240 lbs. at	$41.12	$25.48	
Silage	5,440 lbs. at	4.39	11.93	
Other succulents	400 lbs. at	4.00	0.80	
Hay	3,500 lbs. at	11.94	20.93	
Other dry forage			0.51	
Pasturage			6.95	
Total food cost				$66.60

LABOR COST

Man labor	158 hours at	$0.219—	$34.53	
Horse labor	8 hours at	0.141	1.09	
Total labor cost				$35.62

OVERHEAD COSTS

Interest on animal inventory	$ 4.44	
Bedding	1.69	
Use of buildings	7.50	
Use of equipment	1.12	
Bull service	1.94	
Interest on feed inventory	0.86	
Miscellaneous costs	3.97	
Total overhead costs		$ 21.52
Managerial ability, business risks		12.37
Total costs		$136.11

AVERAGE RETURNS PER COW

Increased value of cows	$ 7.28	
Manure	12.96	
Calves	3.52	
Hides and feed bags	0.49	
Total returns for items other than milk		$24.25
Net cost of milk ($136.11 — $24.25)		$111.86

Total production	2,478 qts. 5,328 lbs.
Cost per quart at farm	$ 0.0451
Cost per 100 lbs. at farm	2.10
Hauling charge to station per quart	0.00273
Hauling charge to station per 100 lbs.	0.127
Cost per quart at station	0.0478
Cost per 100 lbs. at station	2.23

There seems reason to believe that the average milk yields obtained in this survey and cited above is nearly, if not quite, a full thousand pounds higher than that which would accurately represent the average production of the cows of the State as a whole. However, they represent what 212 practical farmers owning everyday farmers' herds are

making. They do not represent the results secured by fancy farmers owning high priced stock. They do not represent an impracticable ideal but an everyday practicality throughout Vermont. It does not seem too much to expect that dairymen who hope to continue in and succeed in the market milk business should so breed and feed their cattle as to develop herds capable of even greater production than this. It does not seem too much to say that dairymen who do not strive to increase the production of their cows, in so far as conditions admit of their doing so, should enter upon other lines of endeavor. Of course competition eventually will force them out of the milk business.

It is well known that the amount of milk a cow makes determines in a controlling degree its cost per quart. The following table drives home this idea.

Group	Number of farms in group	Number of cows in group	Average production	Cost per quart at farm
Under 1800 quarts	28	689	1644 qts. 3535 lbs.	5.78 cts.
1801-2100	26	582	1957 qts. 4208 lbs.	5.00 cts.
2101-2400	49	1061	2247 qts. 4831 lbs.	4.80 cts.
2401-2700	36	734	2521 qts. 5420 lbs.	4.27 cts.
2701-3100	42	914	2862 qts. 6153 lbs.	4.36 cts.
Over 3100	31	670	3582 qts. 7701 lbs.	3.77 cts.
Average	212	4650	2478 qts. 5328 lbs.	4.51 cts.

Some dairymen have argued in shortsighted fashion that the sales price of milk should be set so high that all market milk makers, good, bad and indifferent, large and small, should make a profit. They seem to forget that consumers have rights, that sales prices in other lines of business are not determined by the capabilities of the inefficient but of the efficient operators who are able to make a profitable output at a less cost. Neither on the other hand should the lower production costs of the more highly organized and efficient dairies become the basis of price determination, since such conditions cannot universally obtain. Neither extreme affords a safe basis for the computation of cost charges. The material contained in this report represents an effort to secure data which may serve as a fair basis for milk bargaining.

If one is to attempt to estimate the costs of making market milk in the immediate future, it seems especially important that valid quantity figures be secured at the outset. In other words, it is more important to know that 1¾ tons of hay were fed a cow during the year than to know that hay worth $20.93 was fed. Ruling prices may be applied with safety and with a fair assurance as to their accuracy.

The cost of making milk for any given period then may be readily determined. In order to facilitate such a computation, the following table has been prepared, using the data secured during the survey now under discussion. The prices used for grain, roughage, labor, etc., are not those arrived at in the survey which, it will be remembered, covered the year from May 1, 1916 to April 30, 1917. To employ these figures in this year of rapid changes during the fall and winter of 1917 would be farcical. They have been modified according to the carefully formed judgment of the writers after a study of the survey data and conference with several of their associates.

OUTLINE FOR COMPUTING COST OF MILK PRODUCTION

PROBABLE COST OCTOBER 1, 1917			COST AT SOME FUTURE DATE		
Food cost			*Price per Ton*		*Value*
Grain, 1,240 lbs. @ $50	$31.00		0.62	@	.....
Silage, 5,440 lbs. @ $5	13.60		2.72	@	.....
Other succulents (green oats, etc.), 400 lbs.	0.90		....	@	.....
Hay, 3,500 lbs. @ $13	22.75		1.75	@	.....
Other dry forage (corn fodder, straw, etc.)	0.55		....	.....	.....
Pasture	7.30		....	.....	.....
Total food cost		$ 76.10			
Labor cost			*Hrs.*	*Price*	*Value*
Man labor, 158 hours @ 25c	$39.50		158	@	.....
Horse labor, 8 hours @ 18c	1.44		8	@	.....
Total labor cost		$ 40.94			
Overhead costs					
Depreciation on cows 12% on $77.41	$ 9.29		12% on	.....	.....
Interest on cows 6% on $77.41	4.64		6% on	.....	.....
Bedding	1.86			.....	.....
Use of buildings	8.25			.....	.....
Use of equipment	1.29			.....	.....
Bull service	2.13			.....	.....
Interest on feed inventory	1.03			.....	.....
Miscellaneous costs	4.57			.....	.....
Total overhead costs		$ 33.06			
Managerial ability and business risks		15.01			
Total cost		$165.11			
RETURNS OTHER THAN MILK					
Increased value of herd	$.....			.....	.....
Manure	12.96			.....	.....
Calf	5.00			.....	.....
Hides and feed bags	.49			.....	.....
Total cost		$ 18.45			
Net cost of milk		$146.66			

Milk production (qts.)	2,478
Cost per quart at farm	$0.0592
Cost per 100 pounds at farm	$2.75

HOW TO USE THE TABLE

To make this table apply to local conditions, the right hand spaces may be filled in with such figures as individual judgment and experience dictate.

"Side line dairymen" will do well to make a close study of production costs, for then they will come to realize that the selling price of milk does not alone represent profit and that if they are to succeed in the business they must meet all legitimate expenses.

A reasonable profit on the enterprise should be allowed the dairyman. It is entirely fair to assume that any farmer who is capable of operating a complex dairy business could secure a commission of 10 percent on almost any business of equal size in which he embarked. Unless this is forthcoming from the farm, he is likely to turn to other fields, in which event a less efficient man takes his place and costs increase to a higher level than that occupied by cost and profit together under efficient management. Obviously from the standpoint of the milk-consuming public, it is desirable that the dairy business be made sufficiently attractive to hold the intelligent operator.

It should be clearly understood that this study was made in Vermont, that it deals with conditions as they exist in Vermont, and that the results are neither necessarily or probably applicable elsewhere. For example, it costs more to make milk in Southern New England than it does here. All that is claimed for the outcome is that it portrays with reasonable accuracy the average cost of making market milk on 212 Vermont dairy farms scattered all over the State during the year ending April 30, 1917, and that the estimate as to probable costs on these farms at the present writing, October 1, 1917, was determined by carefully considering the existing situation on the feed, labor and other markets in the light of the results secured in the spring study.

The following pages contain a series of forms for reporting cost of milk production data, being those adopted for uniform usage throughout the New England States in the 1917 spring study and supplied by the Agricultural Committee of the Boston Chamber of Commerce. It is hoped that every recipient of this bulletin who is a market milk maker or, indeed, carries on any sort of dairying operations and who possesses accurate data as to the actual cost of producing milk on his own farm will fill out these forms and mail them (signed) to the Extension Service, Burlington, Vermont. If a considerable number of Vermont dairymen will do this from year to year a sufficiently large mass of data can be thus accumulated to enable the University to furnish reliable information relative to the cost of making milk.

BLANK FOR STUDYING COST OF MILK PRODUCTION

Record for year ending.....19....County.....

Name..... P. O.....

Acres farmed.....Miles to shipping station.....

COW COST—Inventories, Sales and Purchases

	Number	Value	Total		Number	Value	Total
Cows on hand beginning of year	....	$....	$....	Cows on hand end of year..	....	$....	$....
Cows purchased...	....	....	....	Cows sold.....	....	....	....
Heifers that became cows**	....	....	....	Cows died.....	....	....	....
Total	....	$....	$....	Total	....	$....	$....

Increased value $..... Decreased value $.....

Average inventory of cows, No..... Value, $..... Interest @ 6%, $.....

**Give value of heifers at time of freshening.

FOOD COST—Grain used by cows. (Do not include grain fed bulls or young cattle)

Purchased grain	Tons	Value per ton (Year)	Total
Bran or (wheat) mixed feed.....	.....	$.....	$.....
Cottonseed meal	.....	.....	.....
Distillers' dried grains	.....	.....	.....
Gluten feed	.....	.....	.....
Proprietary feeds (give brand name)..	.....	.....	.....
.....	.....	.....	.....
Total grain purchased for cows....	.....	$.....	$.....
Home-grown grain			
Corn	.....	$.....	$.....
.....	.....	.....	.....
.....	.....	.....	.....
Total grain fed cows.....	.....	$.....	$.....

Silage and other succulent food used by cows

	Tons		
Corn silage	.....	$.....	$.....
Soiling crop (name it)	.....	.....	.....
Roots	.....	.....	.....
Total succulent food used by cows.	.....	$.....	$.....

Dry forage used by cows

	Tons		
Mixed hay	.....	$.....	$.....
..... hay (name it)	.....	.....	.....
.....	.....	.....	.....
Corn stover	.....	.....	.....
..... straw (name it)	.....	.....	.....
Total dry forage used by cows.....	.....	$.....	$.....

Average investment in feed and supplies used by cows, $.....

Interest at 6%, $.....

PASTURE COST—Pasture used by stock

Acres ..... Value per acre $..... Total value $.....

Interest and taxes at ....%	$.....
Annual fence costs	.....
Paid for pasture	.....
Other pasture cost	.....
Total	$.....
Received for pasture	$.....
Difference = Cost	$.....
Proportion of cost charged to cows	$.....

BEDDING COSTS—Bedding used by cows

	Amount		Value	Year Total
Straw	.....	Tons	$.....	$.....
Shavings	.....	Bales	.....	.....
Sawdust	.....	Loads	.....	.....
	.....		.....	.....
Total	.....		$.....	$.....

LABOR COSTS—Labor on cows

*Human labor charged @ ...c per hour. Horse labor charged @ ...c per hour

Human labor	Pasture season Hours per day	Days	Total hours	Winter period Hours per day	Days	Total hours	Total Hours	Cost
Milking	....	....	....	....	....	....	....	$....
Other chores†	....	....	....	....	....	....	....	....
Hauling milk.....	....	....	....	....	....	....	....	....
Hauling feed and bedding	....	....	....	....	....	....	....	....
Total human labor	....	....	....	....	....	....	....	$....
Horse labor								
Hauling milk	....	....	....	....	....	....	....	$....
Hauling feed and bedding	....	....	....	....	....	....	....	....
Other labor	....	....	....	....	....	....	....	....
Total horse labor	....	....	....	....	....	....	....	$....

*As an aid in making estimates the following probable costs are given: Man labor 25c per hour; horse labor 18c per hour; cost of growing and storing silage corn $5.00 per ton.

†Feeding, care of barns, cows, products and utensils, etc.

BUILDING COSTS—Buildings used by cattle

Value of buildings	Beginning of year	End of year
Cattle barns	$.....	$.....
Milk house	.....	.....
Ice house	.....	.....
Total	$.....	$.....
Average value	$.....	
Interest and taxes @ ....%		$.....
Insurance		.....
Yearly cost of building repairs*		.....
Decreased value		.....
Total		$.....
Increased value		$.....
Difference = Cost		$.....
Proportion charged to cows.		$.....

EQUIPMENT COSTS—Equipment used by cows

Inventory	Beginning of year	End of year
Cans and other dairy utensils	$.....	$.....
Milk wagon	.....	.....
Barn tools and equipment	.....	.....
Total	$.....	$.....
Average value	$.....	
Interest		$.....
Equipment purchased		.....
Repairs		.....
Decreased value		.....
Total		$.....
Increased value		$.....
Difference = Cost		$.....

*Materials purchased, materials used from farm, all labor employed, etc.

BULL SERVICE COST

Estimate the net cost of keeping herd bulls. Include under costs, feed, bedding, pasture, labor, use of buildings, interest, depreciation, etc. Deduct value of manure, receipts from service, appreciation, and any other returns..... $.....

MISCELLANEOUS COSTS FOR COWS—(List all costs not previously given)

Insurance for cows	$.. .....
Medicines and disinfectants	.....
Veterinarian's fees	.....
Feed grinding	.....
Ice, ... tons	.....
Cow test association dues, etc.	.....
Paid for milk hauling	.....
Salt and stock foods	.....
Association fees and dues	.....
Taxes on cows	.....
Water	.....
Artificial light	.....
.....	.....
.....	.....
.....	.....
Total	$.....

RETURNS OTHER THAN MILK

Cow increase (page ....)	$.....
Manure, ... tons @ $.....	.....
Cow hides	.....
Calves, No. ..... @	.....
Cow feed bags, ... @	.....
Total	$.....

DISPOSAL OF MILK

		Year	
Milk used in house.....	.....qts.* @	.....	$.....
Milk furnished to hired help.	.....	.....	.....
Milk fed to stock	.....	.....	.....
Wholesale milk sold	.....	.....	.....
Total milk produced	.....qts. @	.....	$.....

*To change to pounds, multiply quarts by 2.15. To change pounds to quarts, divide pounds by 2.15.

SUMMARY

Costs	From page	Cost ..... cows Year total Amount	Value
Cow decrease	....	.....	$.....
Interest on investment in cows.....	....	.....	.....
Grains	....	.....	.....
Succulent feed	....	.....	.....
Dry forage	....	.....	.....
Interest on investment in food and supplies	....	.....	.....
Pasture	....	.....	.....
Bedding	....	.....	.....
Human labor	....	.....	.....
Horse labor	....	.....	.....
Use of buildings	....	.....	.....
Use of equipment	....	.....	.....
Bull service	....	.....	.....
Miscellaneous costs	....	.....	.....
Total costs		.....	$.....
Returns except milk	....	.....	$.....
Difference = Cost of milk.....		.....	$.....
Total milk receipts		.....qts.	$.....
Cost per quart.....		.....	$.....

Hauling cost per 100 lbs. ..... per qt. .....

21

MARCH, 1918 BULLETIN 210

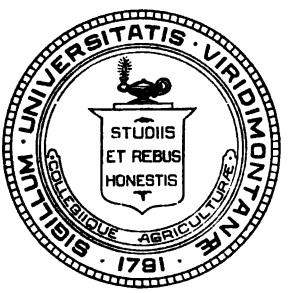
University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

A STUDY OF THE FRUSTUM FORM FACTORS OF HARD MAPLE AND YELLOW BIRCH

B. A. CHANDLER



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Syracuse
College of Forestry - Vermont
1-27-1934 ( )

BULLETIN 210: A STUDY OF THE FRUSTUM FORM FACTORS OF HARD MAPLE AND YELLOW BIRCH

By B. A. Chandler, formerly Acting Forester

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I. INTRODUCTION

1. ORIGIN OF PROBLEM

The writer had charge of the estimating work on the State Forests of Vermont as well as elsewhere from 1912 to 1917. During that time the several volume tables for old growth hardwoods were employed, but with thoroughly unsatisfactory results. It seemed so useless to attempt to make further estimates with existing volume tables that as a temporary expedient a tentative working basis was secured from the data obtained by measuring in the fall of 1914 somewhat less than 50 yellow birches (*Betula lutea*) and hard maples (*Acer saccarum*). Frustum form factors were computed from these measurements and applied to a table of frustum volumes, based on a local top diameter curve. Notwithstanding the small number of trees used as a basis of computation, the results secured were more satisfactory than those afforded by the use of any of the volume tables then extant.

The need of more exact volume data for these species was so evident that definite study of this problem was undertaken in the fall of 1915 and measurements made during two years of more than 1,200 trees.

The direction which this study took was suggested by the work of Schiffel (10) in Germany and Johnson (8) in Sweden.

2. FAILURE OF VOLUME TABLES BASED ON DIAMETER AND HEIGHT

Earlier European tables, based on diameter breast height (d. b. h.) and height of trees, although constructed for and used under much more uniform conditions of tree growth than exist in this country, and from the measurements of thousands rather than of hundreds of trees, have proved so uniformly unsatisfactory that foresters have been long hunting for some third factor to use in classifying trees for volume data. Clark (5) has discussed briefly the development of these studies previous to Schiffel's later work.

Many of our American tables have been based on the measurements of only a few hundred trees, which were averaged into diameter and total height classes regardless of taper or form. Notwithstanding these limitations these tables have given fair satisfaction when used under the following conditions:

(a) Where timber is so cheap that only a rough estimate is needed or justified.

The writer is indebted for counsel to Prof. Evan Thomas of the Chair of Mathematics and Mechanics of the University of Vermont and State Agricultural College.

(b) Where the top diameter determines the merchantable height limit, in contrast to the situation which obtains where the large limbs determine the merchantable height.

(c) Where separate tables are used for each quality site.

Wherever the top diameter limits the merchantable height, trees usually have a distinct central stem throughout their total height, and a total height grouping results automatically in a taper grouping. These conditions exist largely in softwood stands.

Our methods with hardwoods have been more extensive than with softwoods. Lacking adequate volume tables, it has often been the practice to estimate the top diameters of logs in the standing trees which later have been scaled by some log rule. A few of the earlier tables based on diameter only are still being used in special locations by individuals who have worked out correction factors of their own. A timber cruiser in Northern New York and Vermont uses a table made in Herkimer County, N. Y., from mill scales, culling them 25 percent. These tables are printed in Woodman's Handbook (U. S. For. Ser., Bul. 36 [1910]).

At a somewhat later time, hardwood tables were constructed, based on the principle used in the formulation of many softwood tables, namely, averaging trees by diameter breast height and total height group. However as a matter of fact these tables proved to be even more useless than those based on diameter alone for the reason that while they appeared to be more accurate than the latter they were based on a false hypothesis.

Somewhat more satisfactory tables were then constructed, based on diameter breast high and merchantable height. Perhaps the most nearly accurate of these are the so-called Frothingham tables published in manuscript by the United States Forest Service. However, these also failed to furnish entirely satisfactory results for the fundamental reason that all trees of a given species, diameter and height do not possess the same form and taper. Table I shows that the difference between the extremes of a given average ratio of top diameter to diameter, breast high, is sometimes over 0.200 while the corresponding figure for the frustum form factors may be as high as 0.300 and is often over 0.200. Such diversities are too great to permit the indiscriminate lumping of all such trees into common height classes, as is clearly set forth later on in this article.

No one has contended that a volume table will give accurately the volume of individual trees, but everyone has assumed that the errors of

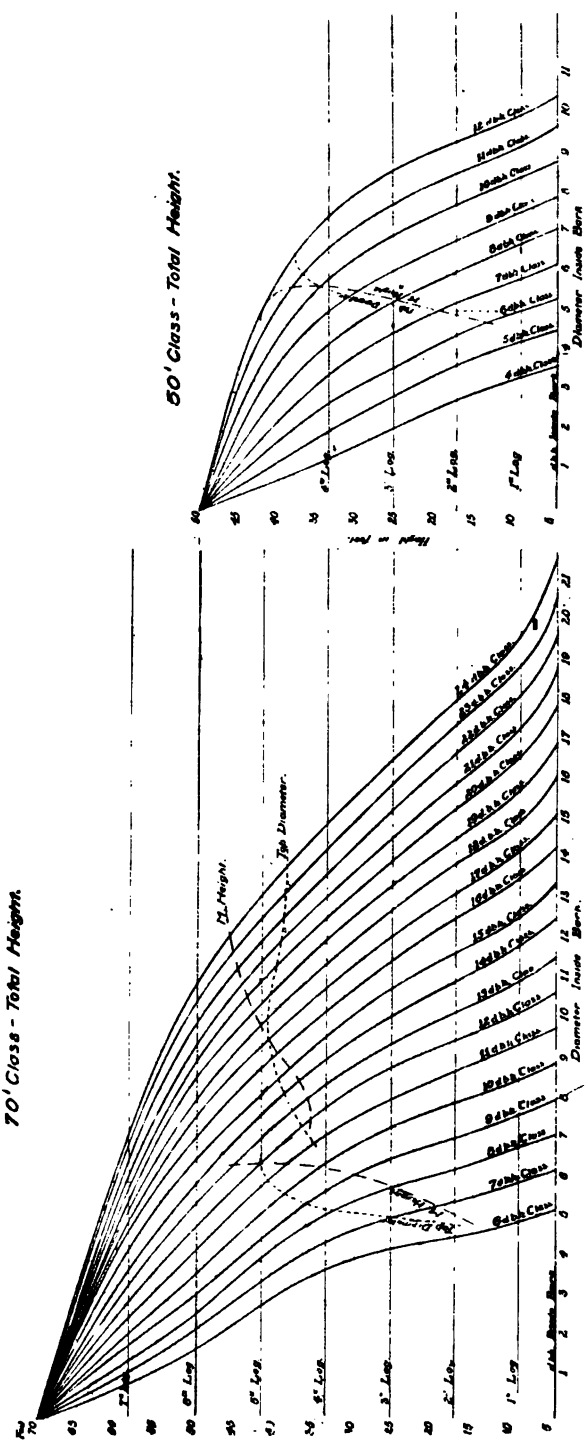

PLATE I.—Showing top diameter and merchantable height curves from a local site drawn across reproductions of taper curves. From U. S. D. A., Bul. 285 (1916).

In order to test these tables for use in Vermont, the trees which were measured for this study in one locality were grouped. It was felt that these trees would fairly represent those which might have been calipered on a strip survey. Both merchantable height and top diameter curves were made representing these trees. These were drawn across reproductions of the above mentioned taper curves and failed to coincide even approximately except with those taper curves representing the lowest total height class (see plate I). As these trees represented site I for hardwoods in Vermont, it seems evident that the tables made from these taper curves are inapplicable to 90 percent of Vermont hardwood stands.

If, then an adequate volume table based on diameter and height is to be attained, it will be necessary to develop an expensive and complicated system. The data must be kept in the taper curve form and be re-scaled whenever a new log rule is used or market conditions change. At least two sets of taper curves must be available for each species, for each quality site; one for old growth and one for second growth. Probably more than two would be needed later divided on the basis of age. Such a system would be costly, complicated and impossible.

3. TYPE AS A UNIT OF AREA IN ESTIMATING

Not only do great variations in type exist over the areas to be estimated but they exist in bole and taper in culled stands on a single quality site. It is not uncommon to find many trees on a quality II site with heights corresponding to the average on a quality III site. Furthermore, within this short height class there is a wide range of taper. This condition is due to the culling of the stand of its softwood and best hardwood 30 to 40 years ago. Many of the suppressed trees which would have died if the stand had not been opened up, have recovered sufficiently to continue diameter growth but have not reached a normal height for the site on which they are growing. The inevitable results of this condition are a short merchantable height, a short total height and a resulting heavy taper. Other trees in the same stand were young enough to recover completely. Some of these latter enjoyed an excessive amount of room in which to grow so that while they reached normal total height for the site they also developed such large crowns that their merchantable heights are very short. These large crowns result in rapid diameter growths and very full boles. Under such conditions the type as the unit of area for estimating is quite

useless. It becomes necessary to caliper the trees into different taper classes and to make a separate height curve for each class. (See plate II). It is practically impossible in a stand of this character to

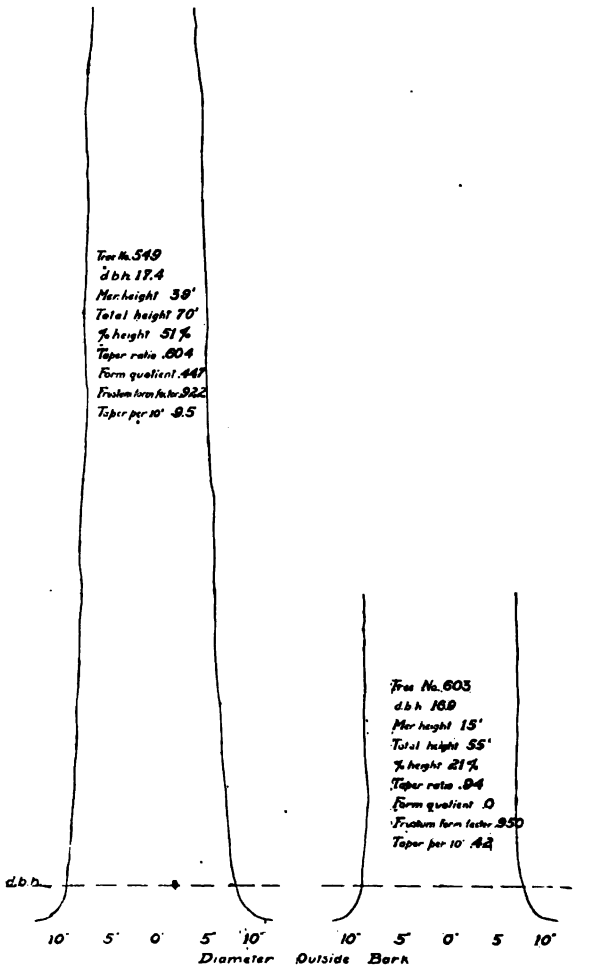

PLATE II.—Showing diagrams of two actual trees which, because they belong to the same diameter breast high class and grew on the same site, would be tallied as of equal volume by the ordinary method of using the general volume table based on diameter and merchantable height.

construct a height curve which will be a true average, and it is even more difficult to determine the average taper for such a stand. Even if it were possible to determine the average there would be only one chance in a thousand that it would correspond to the average taper of a volume table based on diameter breast high and height.

In such stands it becomes necessary to abandon the type as a unit of area for estimation. The trees of each form must be tallied separately and to each form must be accorded its own height curve and volume table or form factor. The use of one volume table with separate height curves alone will not answer here any more than for different sites, for all bole forms and tapers are averaged together. This results in an overestimate of the more poorly formed trees with heavy taper and an underestimate of the full boled trees.

4. LOCAL VOLUME TABLES

Since the general volume table which is based upon diameter and merchantable height obviously cannot be adapted to wide ranges of market conditions, to diverse log rules, or even to different forms of timber found in a single type, the local volume table, made in accordance with the data secured from local lumbering operations or from those conducted on similar sites, would appear to be the only satisfactory solution of the problem. However the formulation of such local tables, constructed from the data secured by measuring the trees as they are felled, is impracticable:

(a) In case the area to be estimated is small and the value of the timber does not seem likely to justify the expense.

(b) In regions where no cutting for the particular market for which the estimates desired is being done.

On the other hand it should be remembered that at times an estimate is necessary to determine whether sufficient stock is available to start some new wood using industry in a region where no cutting is being done. When making working plans it is always desirable to take cognizance of future possible markets as well as of the present ones.

Since neither the general table based on diameter and height, the taper curve, nor the local volume table solves the problem, it seems necessary:

(a) To determine the different factors which influence volume.

(b) To attempt to express these factors independently of each other.

(c) To devise some means whereby they may be combined into volume tables which will estimate fairly the average value of a type, or particular class within a type, for any given market whether actual or assumed.

5. FACTORS WHICH CONTROL VOLUME

Diameter and height have been considered the only volume factors with which it was necessary to deal in the construction of American volume tables. However, as has been set forth in sections 2 and 3 of the introduction, other factors must be taken into consideration. The writer believes that there are two such factors, namely, taper and bole form. The ordinary conception of taper, however, includes both taper-proper and bole form.

In order to obtain a clear idea of the real meaning of taper the merchantable length of a tree above diameter breast high must be considered as the frustum of a perfect cone. Taper, then, becomes the rate of decrease in diameter in this frustum. This decrease in diameter may be expressed either as the ratio that any given diameter bears to the diameter at breast height, or as the amount of taper per standard unit of length. This latter method of statement is the one in more common usage, but, as the writer will endeavor to prove later, the former method is the more accurate of the two and develops much simpler formulas.

The degrees of departure from the perfect cone frustum is the other new factor to be considered, namely, that of bole form. This degree of departure is measured by the ratio of the volume of the tree to the volume of the frustum of the cone having the same dimensions. This is called the frustum form factor (f. f.). The method employed in this study in computing this factor differs slightly from that used by Chapman (2) and Bruce (1) in that only those sections of the tree above diameter breast height were used. Hence it is a measure of the form of the tree above diameter breast high or of that section of the tree which may be held to be reasonably free from the influence exerted by root swelling. The form factor figured in this way when applied to the volume of a cone frustum having the same top diameter, diameter breast high, and taper above diameter breast high, produced to the stump, gives a volume slightly less than that of the corresponding tree when the form factor is less than unity. This factor differs from the absolute diameter breast high cylinder form factor in that the latter is an expression of both form and taper. (See Formula II). This conception of the factors influencing volume was kept in mind throughout the study now under review from the beginning of the collection of data to the final shaping of the curves.

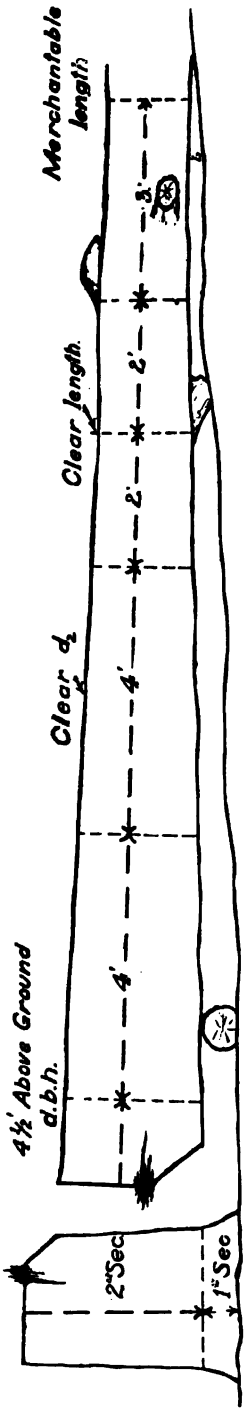

PLATE III.—Illustrating field measurements.

II. COLLECTION AND COMPUTATION OF DATA

The field studies upon which this article is based were made in September-December, 1915 and 1916. The field crew was sent into five different counties in the northern, central and southern portions of the State. Twelve hundred and thirty-one trees, including 663 yellow birch, 435 hard maple and 133 beech were carefully measured. Rather more than two-fifths of the trees were measured in Somerset, Windham County, and were located on quality II and III sites; rather more than one-third in Montgomery, Franklin County, on quality I and II sites; about one-sixth in the unorganized town of Lewis, Essex County, on quality I and II sites; and the residue, some 70 trees, were measured in Worcester, Washington County and Stowe, Lamoille County.

H. H. Squire, B. S. (Vermont, 1914) had charge of the collection of the field data, being assisted in the fall of 1915 by H. L. Ames, B. S. (Vermont, 1911) and in the fall of 1916 by R. S. White.

The data for this study were collected on the regular form used by the Federal Forest Service in determining volume measurements. The first diameter measurement was taken at the point at which the stump should have been cut, the second at diameter breast high and the other measurements every four feet up to the stem. (See plate III). Thus the length of the first two sections added always equalled four and one-half feet, whereas other sections were four feet long except at points where it was necessary to make a shorter section at clear or merchantable heights. Two diameter measurements at right angles to each other were taken at each point and each measurement was recorded in the field book so that the averaging might be checked. Besides

these measurements a "clear d_2" (diameter half way between diameter breast high and clear height) and "merchantable d_2" (diameter half way between diameter breast high and merchantable height) were taken on each tree. The length and width of the crown were measured but no diameters were taken above merchantable height. Clear height was defined as the point where the limbs became large enough so that the knots would lower the grade of the lumber after the slabs were removed. Merchantable height included all of the stem of the tree up to the point where the limbs became so large or numerous that the material was valueless except for wood. In a few trees the whole stem was merchantable until it reached the diameter limit for novelty stock.

The data for each tree were transferred later and handled as follows:

(a) The volume in cubic feet above diameter breast high of each tree for both clear and merchantable height was computed. Often the two coincided.

(b) The volumes in cubic feet of the frustums of cones corresponding to the clear and merchantable heights above diameter breast high were computed.

(c) The volumes in cubic feet of the cylinders having diameters equal to diameter breast high and heights corresponding to the clear and merchantable heights above diameter breast high were computed.

(d) The values representing both the clear and merchantable volume of each tree were divided by those indicating the volume of the corresponding cone frustum giving a clear frustum form factor and a merchantable form factor. The symbol (f. f.) is used in the text for this form factor and, unless otherwise noted, refers to the clear frustum form factor.

(e) The figures representing each tree volume were divided also by those representing the corresponding cylinder volume giving a cylinder form factor (c. f.).

(f) The figures representing d_2 measured in the field, minus the corresponding top diameter, were divided by those indicating diameter breast high minus the same top diameter, giving a ratio called the form quotients (q_2). Plate IV clearly indicates that subtracting the top diameter out of both d_2 and diameter breast high, is equivalent to the removal of a cylinder having a diameter equal to the top diameter. The division of these remaining values gives a form quotient for clear or merchantable height which corresponds to the one used by Jonson

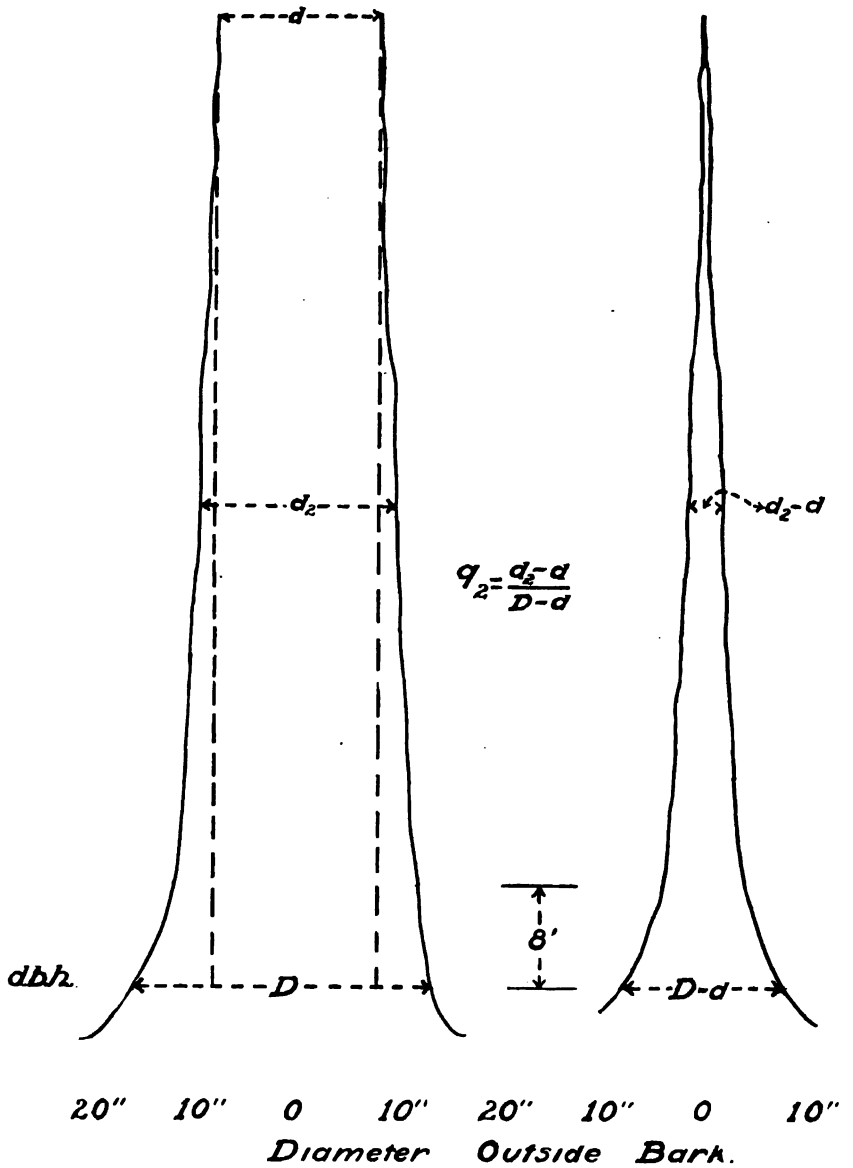

PLATE IV.—Illustrating merchantable length form quotients.

(8) for total height. It is more erratic for the reason that the same linear departure in d_2 is divided by a smaller number.

(g) The average taper per ten feet of both clear and merchantable height also was computed.

(h) The ratio of top diameter to diameter breast high was computed for both clear and merchantable height. This ratio is called a taper ratio and is designated by the symbol r.

III. THE FRUSTUM FORM FACTOR

Of the four factors directly influencing merchantable volume, namely, diameter (diameter breast high), height, taper and bole form, the latter is the only one which is unnecessary for computing the volume of the corresponding cone frustum. In so far, then, as the first three factors are concerned, the exact volume of a tree showing any possible combination of these factors can be computed by mathematical calculations. Therefore, if the laws by which the frustum form, it will be possible to calculate the volume of the merchantable length of any tree regardless of what combination of these factors it exhibits. Such a discovery and expression form the main object of this study.

1. THE ERROR CAUSED BY IGNORING THE FRUSTUM FORM FACTOR

It is obvious that when the frustum form factor equals unity it may be ignored without introducing an error. (See plate V, fig. 2). However, the extent of the error thus introduced increases as the frustum form factor value departs from unity in either direction. If these values so vary that on any given area, being estimated, the average equals unity, the several errors naturally would be compensatory. However, it was found in handling the data in the present study that fully 90 percent of the frustum form factors were less than unity; consequently it seems safe to assume that for old growth yellow birch and hard maple, error elimination through compensation does not obtain. Since the true volume equals the volume of the frustum multiplied by the frustum form factor, the measure of the percentage of error equals the difference between the frustum form factor and unity divided by the frustum form factor multiplied by one hundred.

$$\text{Percent error ignoring f. f.} = \frac{1 - \text{f. f.} \times 100}{\text{f. f.}}$$

Example

$$\text{f. f.} = 0.850 - \frac{1 - 0.850 \times 100}{0.850} = 17.6\%$$

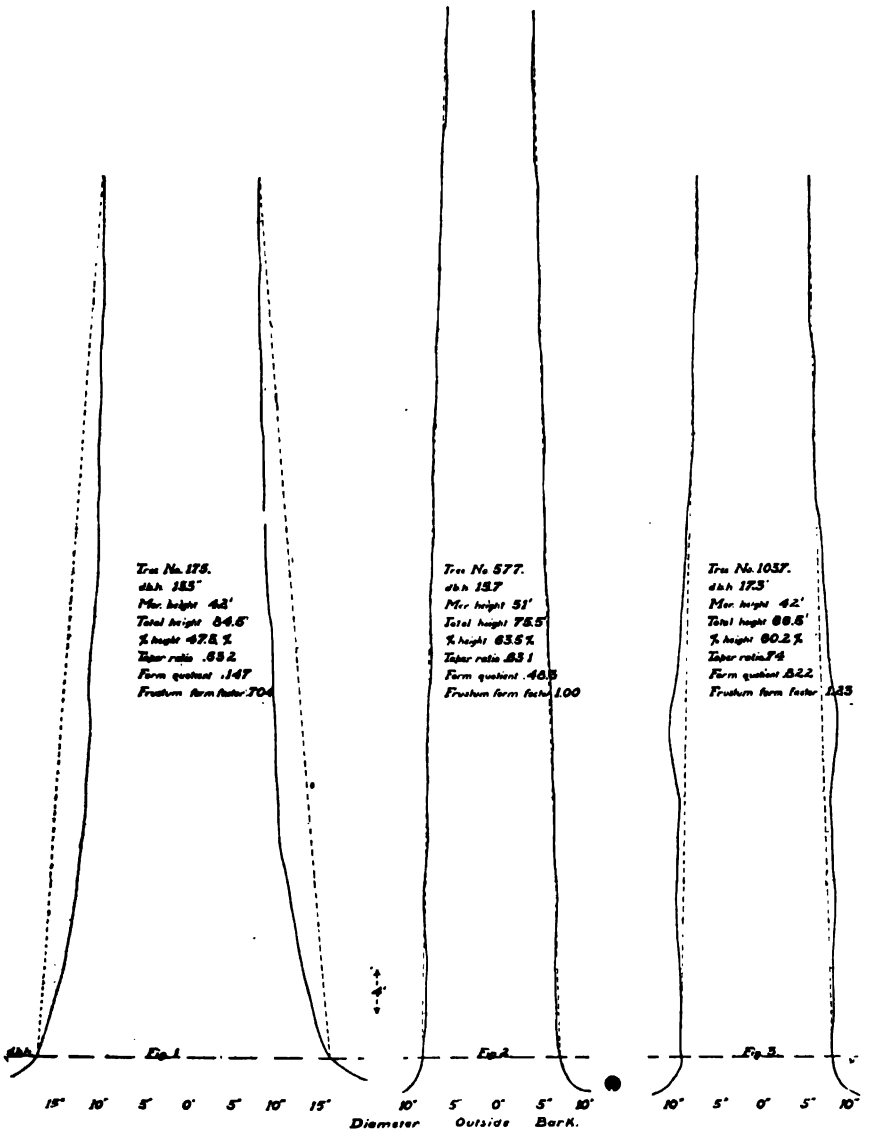

PLATE V.—Actual tree diagrams.

Figure 1. Approaches form of frustum of a nelloid. Figure 2. Approaches form of frustum of a cone. Figure 3. Approaches form of frustum of a paraboloid.

The smallest values for the frustum form factors found in this data were around 0.700 which would give a percentage of error of 43.

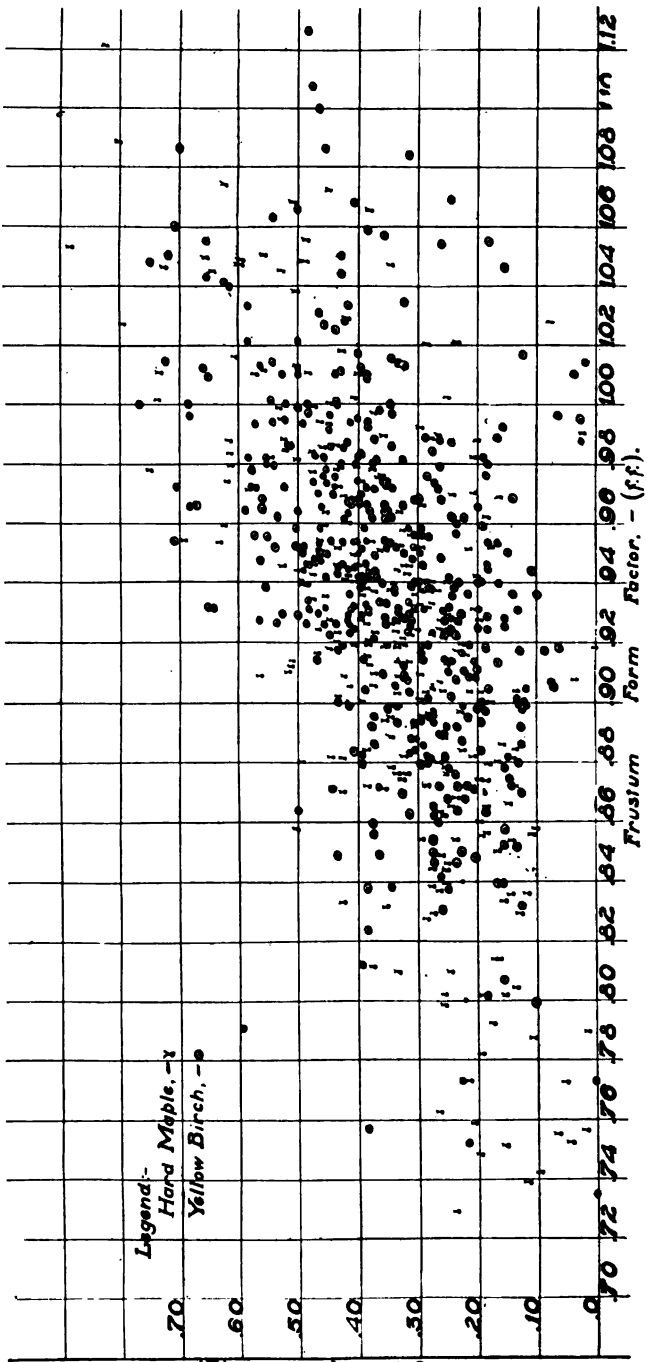

PLATE VI.—Individual trees plotted by species. Note (1) that symbols for each species are distributed uniformly over whole field, showing lack of influence of species upon factors involved; (2) the wideness of the plotted field showing that other factors are involved.

2. FRUSTUM FORM FACTORS DO NOT VARY WITH SPECIES

The frustum form factors for each species were averaged separately by diameter breast high and three-foot height classes (table I).[1] The range of values and the average of different diameter breast high and height classes show no apparent relationship to species.

While studying the factors which influence the frustum form factor, the frustum form factor values of individual trees were plotted on the abscissa and the form quotients on the ordinate, different symbols being used for each species. These data are displayed in plate VI. Since the symbols representing the different species are so interrelated it seemed evident that species is not a vital factor in the variation of the frustum form factor, and, therefore, the data secured with the two species were handled as a unit during the remainder of the study. No curves were drawn using these data, for the wideness of the field indicated that the variation of the form quotient were not a complete expression of the variations of the frustum form factor.

Later, after the relationship between the form quotient taper ratio and the frustum form factor was determined, the individual trees averaged into the 0.950 and 0.850 f. f. curves were plotted by species with the result shown in plate VIII. Of course the exhibition made in this plate does not prove that species does not influence the value of the frustum form factor, but the writer is constrained to feel that its response to conditions brought about by differences in soil, moisture, light, etc., is much more pronounced than its response to species.

3. FRUSTUM FORM FACTORS DO NOT VARY WITH CLEAR HEIGHT OR DIAMETER BREAST HIGH

Neither Bruce (1 and 2) nor Chapman (3) found any relationship existing between frustum form factor and height for the species with which they worked. Chapman has shown that the apparent variation with diameter breast high found by Korstian (9) was in reality a variation in top diameter which indirectly affected the form factor.

Table I shows the data collected for this study grouped into diameter breast high and clear height classes and the form factors averaged for each class. No relationships between the frustum form factor and

[1] The several tables referred to in the text and listed in the appendix are not printed. They are voluminous almost beyond words to describe. They are deposited in a fire-proof vault in Morrill Hall at this institution where they can be consulted by any one who may be interested. They will be sent by registered mail or insured express to any responsible person who may request them, to be returned in similar fashion.

either diameter breast high or height is apparent from the variation of these averages. Furthermore, the range in values entering into these averages is greater than it would be if the classification were a natural one.

The fact that height and diameter breast high both cancelled out of the formulas developed in the appendix for the values of the frustum form factor constitutes the final proof that the frustum form factor does not vary with either diameter breast high or height.

4. FRUSTUM FORM FACTORS VARY DIRECTLY WITH THE FORM QUOTIENT

The individual tree data plotted with the form quotients on the ordinate and the frustum form factor on the abscissa showed that the two factors varied directly with each other (see plate VI). However, the wideness of the plotted field indicated that other factors existed which influenced the values of the frustum form factor.

5. VARIATION OF THE FRUSTUM FORM FACTOR WITH THE FORM QUOTIENT AND TAPER RATIO

It is the opinion of the writer that as a matter of fact taper ratio (ratio top diameter and diameter breast high) is a better expression of taper than is its amount per unit of height or per log, although it introduces an entirely new conception. For a given height and diameter the two expressions mean the same thing. After making several unsuccessful attempts to express the variations of the frustum form factor in terms of the taper per unit of height, it became evident that the frustum form factor has a simpler and much more serviceable relationship to the taper ratio than to the taper per unit of height. In all these formulas the height would cancel as a term but would enter in as a part of the expression of taper and make the formula so complicated that it could be of no practical value. Furthermore, as is elsewhere shown, the volumes of trees of the same diameter and height do not vary with taper expressed per unit of height, as they do with the taper ratio.

The relationship between the form quotient, taper ratio and the frustum form factor was discovered by expressing the frustum form factor in terms of the volume formulas of the geometrical figures which resemble trees. It is evident that when the frustum form factor is greater than unity the form of the tree approaches that of the paraboloid, and that when it is less than unity it approaches that of

the neiloid (see plate V). By taking advantage of these facts several interesting relationships were developed which will be discussed further on. Formula I shows the mathematical relationship existing between the form quotient, taper ratio and frustum form factor of geometrical figures.

A study of this formula led the writer to query whether the form quotient and taper ratio were not two factors which might express the variation of the frustum form factor of trees. The measurements of a few individual trees plotted on cross section paper indicated the correctness of the theory. Accordingly the trees were grouped first into frustum form factor classes (0.800, 0.850, 0.900, etc., and each class sub-divided into taper ratio classes (0.600, 0.650, 0.700, etc.). The average values for form quotient, taper ratio and frustum form factors were found for each sub-class, the results plotted and averaged by the solid lines on plate VII. The corresponding curve computed by formula I was plotted in a broken line on the same plate. It will be noticed that the two curves have in each instance practically the same form. It will also be noticed that the difference in value between each set of two curves increases as the frustum form factor value decreases. After making several rather unsatisfactory attempts at formulating an empirical expression for the variation between the mathematical and empirical curves, it was found to resemble a geometrical progression. Owing to insufficient data the curve for the 1.000 frustum form factor could not be located accurately and hence the first term of this progresion had to be computed from the 0.950 and 0.850 curves. The standard formula for a geomatrical progression is $l = ae^{n-1}$ in which a = first term (0.0013), e = ratio (1.34). (See appendix for derivations of these values).

l = the last term, the amount to be subtracted from the value of the frustum form factor as given by formula I to obtain the empirical value.

Plate VIII shows the individual trees of the 0.950 and 0.850 frustum form factor classes plotted in the same manner as were the averages on plate VII, together with the empirical average curves from plate VII. Theoretically, each frustum form factor should take its place above or below its respective curve according as its value is greater or less than the value represented by the curve. For the most part they follow this rule, but there are frequent exceptions. A few of these scattered trees were computed by formula I corrected by the progression, and the volume error found to be about $\pm$ 10 percent

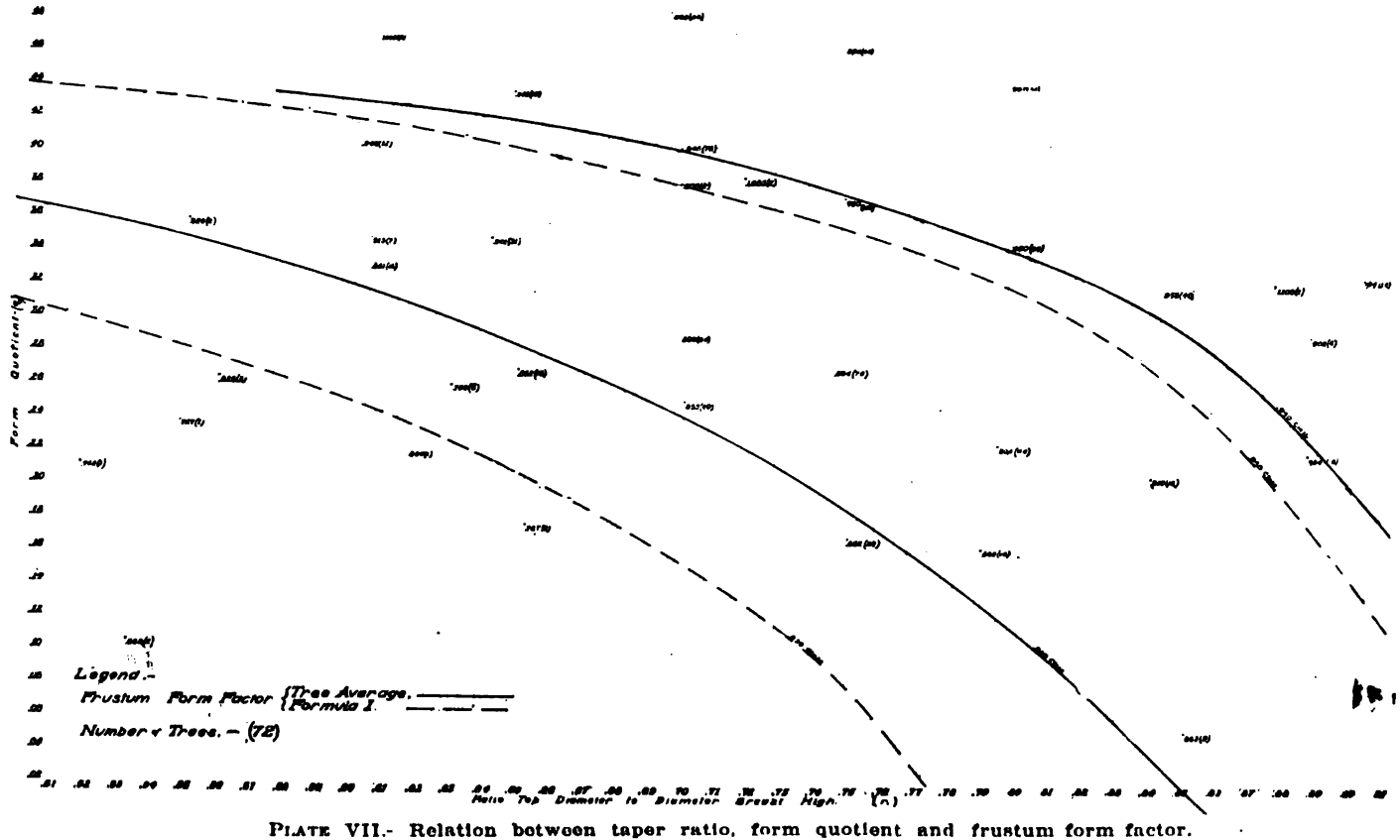

PLATE VII.- Relation between taper ratio, form quotient and frustum form factor.

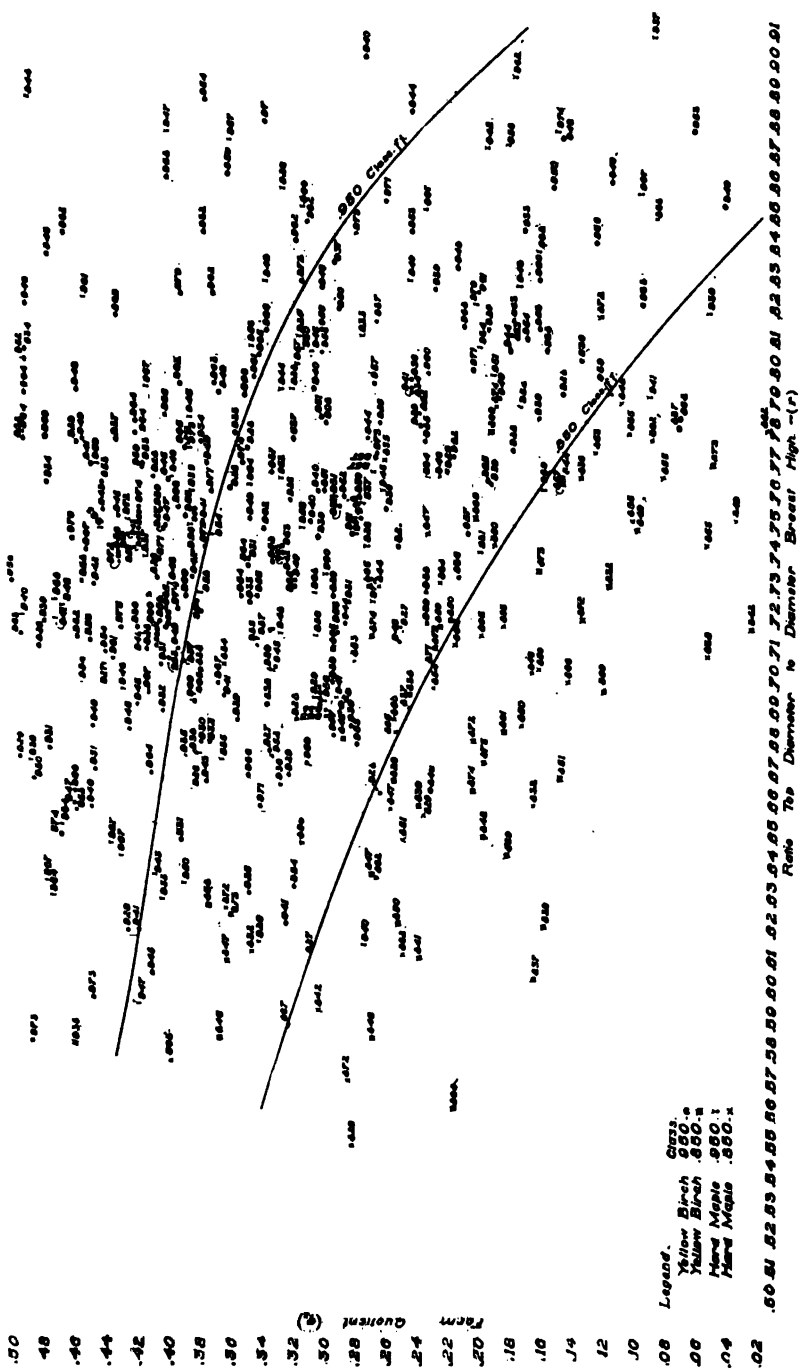

PLATE VIII.—Relation of individual trees to the average curves from Plate VII.

of the empirical value. The form quotient is the unreliable factor which probably is responsible for the results exhibited by these erratic trees. For example, if d_2 falls on a swelling such as shown in figure 3, plate V the frustum form factor value computed by formula I would be considerably too large.

6. OPPORTUNITY FOR FUTURE STUDY

The application of this set of curves and of formula I raises several interesting questions which cannot be answered until more data are secured and further study given to the problem.

1. Would this relationship between the curves from tree averages and formula I hold good for the higher values of taper ratio? In each instance it will be noted that the two curves are of the same form, and that the relationship holds good to the point where the data fail.

2. Is the relationship between the form quotient, taper ratio and frustum form factor found from this data, the expression of a general relationship which will apply to other species and types? The apparent lack of influence of these two species (yellow birch and hard maple) upon the value of the frustum form factor indicates the possibility of eliminating species. If the frustum form factor is not a function of species, it may be purely the result of the response of the tree to the conditions under which it grows. It may also be true that the conditions which produce a certain bole form result in a given relationship between the form quotient and the taper ratio. The relation of the frustum form factor to other species and to particular types will have to be studied before these questions can be answered.

3. Is there some factor of the crown which can be measured more easily than the form quotient and which has sufficient correlation with the frustum form factor so that it can be used in place of the form quotient? Running through these data there appears to be a thread of relationship between the frustum form factor and the depth of crown in relation to total height. It has not been possible to follow the lead at this time. If such a factor could be found, it would be more universally used than the form quotient.

4. Would an empirical expression of these relationships be simpler than a mathematical statement such as is formula I? If it can be shown after more study that the frustum form factor bears a fixed relationship to other factors which can be measured on standing trees, the empirical values of the curve representing that relationship

can be placed on a special slide rule, even though the formula may be rather complicated.

5. Will the same relationship shown by these curves for the clear height of trees hold good when the merchantable height extends above the clear height? A few such trees were measured during this investigation, but not enough study has been made of them to warrant any statement at this time.

The writer is well aware that formula I, further complicated as it is by the correction progression, is too involved to come into general use. He believes however, that the intelligence with which the frustum form factor is used is conditioned upon the fullness with which the laws governing its variations are understood. Eventually these laws will be reduced to some simple form that may be used generally by timber estimators, while for the present in most practical work contentment with more or less approximate values will be necessary.

IV. CHAPMAN'S SUGGESTION

Chapman (3) has made the most helpful suggestion for the use of the frustum form factor which the writer has seen in print. His suggestion is as follows:

"Tables of standard frustum volumes could be prepared, based on d. b. h., assuming that d. i. b. stump = d. b. h. for purposes of the volumes sought. These standard tables should show volumes for frustum for each d. b. h. and 16-foot log length, and for each standard average taper by half-inch (or even quarter-inch) classes, for the standard log rule used in that vicinity. For example:

D. B. H.	Log Length	*Tapers, Standard (beginning at 1")*					
20"	4	1"	1¼"	1½"	1¾"	2"	etc.
Total volume (Doyle rule)		734	671	612	556	504	

For accurate application of this basic table to a given species, the average taper per log would be determined by measuring and comparing the merchantable top diameters with the d. b. h. or even by measuring a large number of logs, or using a dendrometer on standing trees. After selecting the volumes coinciding with this taper, a correction factor or frustum form factor would be applied. In present practice this correction is ignored by most cruisers. For instance, investigation based on the above principles of determining the "true" frustum form factor should show that 0.95 is consistent for longleaf pine, or that 0.9 could be relied upon for certain hardwood species, the local

volume table is obtained, first, by selecting from the above standard table the volumes corresponding with the average taper to one-fourth inch, and then deducting 5 percent, or 10 percent, as above, for the form factor. Where trees differ in form, in degree of utilization, and in standard of board-foot measure applied to their contents, there never can be a universal volume table which can be applied without modification to different species. The above plan may come as near to it as practice requires."

Chapman's suggestion is of more assistance in the solution of the problem of estimation by means of merchantable height than any which has come to the writer's attention. However, it contains two weak features, namely—the excessive computation needed to make the table of cone frustum volumes covering all possible cases and the variation which the frustum form factor exhibits with different taper ratios.

The first weakness becomes evident when it is considered that on some kinds of timber the taper may be as low as one-fourth inch whereas on others it may be as high as four inches per ten feet of height. Indeed, each diameter class will be likely to exhibit five or six different tapers. It is possible by using different log lengths to utilize within two feet of any given point, so that each taper must be scaled for every two-foot height from eight feet upwards. Furthermore, separate tables must be computed for each log rule used.

The second objection to Chapman's suggestion comes to light in view of the results obtained in this study and stated in a previous section. Since the frustum form factor varies as does the ratio of the top diameter to the base diameter (taper ratio), as shown both by the formula I and the empirical curve (plate VIII), a single value for the frustum form factor cannot be used for all tapers. For example, let it be assumed that three trees have equal diameter breast high, form quotient, and height, but different tapers.

Case No.	d. b. h.	q_2	Clear height	Taper 10′ section	Top dia.	r	f. f.	Difference in percentage, 1st standard
1	20.0	0.300	40	¼″	18.2	0.910	0.972	0
2	20.0	0.300	40	1″	12.9	0.645	0.859	—11.7
3	20.0	0.300	40	1¼″	11.1	0.555	0.785	—19.3
4	20.0	0.300	16	1¼″	17.1	0.855	0.956	+21.8*

Neither will a given frustum form factor apply to a given taper of a given diameter at more than one point, for if taper remains constant

*Computed with No. 3 as standard.

the frustum form factor varies inversely as height as appears in the case of the last two trees in the table.

Furthermore, a given difference in the amount of taper per unit of length may make very little difference in volume for short trees but considerable difference for taller trees. For example, two trees having the same diameter breast high, form quotient, and a difference of one-fourth inch in taper per ten feet of height will exhibit an increasing percentage of volume difference with increase in height.

d. b. h.	q_3	Taper per 10′	Clear height	Top d. o. b.	r	f. f.	c. f.	Percentage decrease volume per ¼′ increase taper
20.0	0.300	¾″	16	18.3	0.915	0.974	0.894	
20.0	0.300	1″	16	17.7	0.885	0.965	0.858	4.0
20.0	0.300	¾″	44	14.1	0.705	0.897	0.659	
20.0	0.300	1″	44	12.1	0.605	0.830	0.545	17.3

Thus when conditions are found which cause the taper to vary, the form factor must be allowed to vary also.

V. RELATION BETWEEN CYLINDER AND FRUSTUM FORM FACTORS

Due to the fact that a basic table of cylinders can be computed much more easily than one of cone frustums the cylinder form factor always has been the more popular of the two. The great advantage the frustum form factor has had, was that it was thought that the top diameter could be varied without changing the value of the form factor, thus making it more adaptable to different tapers. Therefore a simple expression of the cylinder form factor in terms of the frustum form factor and taper, as shown in formula II (see Appendix), makes available the advantages of both the cylinder form factor and the frustum form factor.

In this study the frustum form factor (f. f.) was computed for the section above diameter breast high outside the bark, and therefore the cylinder form factor (c. f.) resulting from the formula might be called the absolute diameter breast high cylinder form factor. If the frustum form factor is computed as suggested by Chapman (3) and Bruce (1 and 2) the resulting cylinder form factor will be the common diameter breast high form factor. This formula has proved so accurate that it has been used successfully in this study as a cross check between (f. f.), (c. f), and (r). It is very simple, especially for slide rule computation.

Formula III converts the frustum form factor computed from the section above diameter breast high to the cylinder form factor which will give the volume of tree with the section below diameter breast high computed as a cylinder.

In order to determine the relative differences between the volumes given by these different methods of computation, the data secured from individual trees were computed by the several methods and compared on the percentage basis. In these comparisons the volume of each tree calculated by adding the sections above diameter breast high and the section below diameter breast high computed as a cylinder was used as a standard. The percentage figures appearing in the next two paragraphs were computed by subtracting the volume by the method in question from the standard. This difference divided by the standard and multiplied by 100, gave the percentage figures.

By this method the frustum form factor computed from the section above diameter breast high applied to a frustum representing the total clear length of the tree with the taper above diameter breast high produced to the stump, gave volumes four percent less than the standard with small values of the frustum form factor (0.700-0.800) and three percent more with large values (over unity). Practically no error was observed in the frustum form factor values in the region of 0.980, 0.990.

The absolute diameter breast high cylinder form factor applied to the cylinder representing total clear height and breast high diameter of the trees gave volumes which were from one to seven percent smaller than the standard, the smaller errors being obtained with large values of the frustum form factor. In this connection it should be noted that formula I, uncorrected by the progression, gives values for the sections above diameter breast high which are too large by about an amount equal to errors noted in previous paragraph for any given frustum form factor. Therefore, in practical work these two differences in volume may be assumed to compensate each other.

The cylinder form factor computed by formula III gives volumes which vary from the standard by plus or minus errors of less than one percent which probably are due to decimals.

Basic tables for yellow birch and hard maple with the proper bark allowance for each have been computed and appear in the appendix. A basic table giving the volume of the cylinder outside the bark also is printed in the appendix.

VI. THE CYLINDER FORM FACTOR

Except for the lack of the correction factor between the empirical curve for the cylinder form factor and the curve derived from the formula, the cylinder form factor can be computed directly by formula IV. Formula IV gives the value for the cylinder form factor which corresponds to the value of the frustum form factor furnished by formula I. In fact, formula IV can be derived by combining formulas I and II. So far as the writer knows there is no reason why this correction for the cylinder form factor cannot be worked out.

The frustum form factor was worked with first because it was a unit factor of volume whereas the cylinder form factor is a composite made up of the frustum form factor and taper ratio as shown by formula II. Formula IV appears to react to much the same influences although in a different degree than formula I. The composite factor probably will be used eventually for practical purposes. The writer feels that during the investigation period it is wiser to keep the factors separated so that they may be handled individually and with exact information as to what is happening to them.

VII. THE USE OF A MILL FACTOR

There are a great number of log rules—nearly 57 varieties of them. Some 15 years ago the Federal Forest Service listed 43 such rules and several have been formulated since that time, including the so-called "Universal" rule, based on direct mathematical calculation and published in bulletin 102 of the Vermont Station by Dr. A. L. Daniels, emeritus professor of mathematics in the University of Vermont. It is claimed for these many rules that they tell the number of board feet in a log. However they differ widely among themselves. Many of them,—perhaps most of them—prove successful and do accurate work under local conditions. Thus, for example, the A rule, based on long time experience in the timberlands of B valley and with sawyer C working in D mill, may be the best for that region, more just in its working than any other; but it may be utterly unfitted for use elsewhere.

Practically all logs are bought and paid for by the use of some log rule; but much dissatisfaction is experienced. Farmers often feel that they do not get all there is in the log; millmen complain of their inability to saw out all for which they are asked to pay. This is the situation which has served to bring out these many rules.

There is no standard log rule today universally applicable to different localities, to different wood using industries, or to different periods of time. Each locality is likely to use its own log rule and a board foot of log in a valley where, for example, the Scribner rule is used, means something very different from a board foot in another section where the Vermont rule is used. Some industries, such as the pulp and novelty mills, use the cord, which is a cubic foot standard. In at least one Vermont valley mills now buy hardwood logs for the general market by the cubic foot.

As closer utilization become possible, the log rule also must be changed or it decidedly underscales. Some millmen, by using rules which are badly out of date as far as utilization is concerned, have dealt unfairly with the men from whom they buy logs. On the other hand, farmers who do not inform themselves as to the amount of culling and degrading which is necessary before lumber can be sold, have created a situation which makes it necessary for millmen to use rules that will allow a safe overrun.

Since no log rule of countrywide application exists, and since a log rule which could be adapted to changing conditions would be as unstable as an India rubber yardstick, it appears reasonable to assert that the cubic foot ought to prove a more satisfactory unit of measurement in timber estimating than a log rule. It is a standard unit of volume with which every locality, industry and period of time are more or less familiar. If the people of any particular region or industry are not familiar with its use for measuring logs, they have the data at hand for figuring out its relation to their local log rule much more accurately than they can determine the relation between their log rule and any other rule. In fact, many of our so-called log rules, for example the Vermont rule, really are cubic rules in disguise.

Any basic table of frustum or cylinder volumes which is intended for more than local use should be expressed in terms of cubic feet. If computed by any given log rule, it is of use only in the region where that log rule is used. If computed in cubic feet, a local factor (mill factor) can be made which not only will convert from cubic feet to the board foot corresponding to the local log rule, but also will allow for the cull necessary in the local timber. To be sure, there is some difficulty in determining this mill factor. It involves local mill scale studies in order to find out the number of cubic feet which actually will saw out of the different grades of logs; but in the writer's judg-

ment such studies are well worth while. However, in the absence of an opportunity to make these, two courses are open:

(a) To disregard cull, as far as the mill factor is concerned, and compute a mill factor for the local log rule. Unless the rule is one which varies directly with cubic feet the mill factor will vary with diameter and, therefore, must be computed for the size of timber in question.

(b) To estimate the mill factor from the external appearance of the timber and from previous knowledge of how such timber opens up.

VIII. APPLICATION TO PRACTICAL ESTIMATING

Estimating methods are still in the process of evolution. First, the forester's rough volume tables replaced all but the best of the old timber cruiser's methods; the tables based on diameter and height soon replaced those based on diameter alone; and now foresters are beginning to learn how to use the frustum form factor. The available material for the use of the frustum form factor method for hardwoods is as follows:

(a) Tables of cylinder volumes (appendix).

(b) Formulas which make it possible to obtain the cylinder form factor from the frustum form factor, and the frustum form factor from the taper ratio and the form quotient, or the cylinder from factor direct.

(c) Mill factors with which to convert cubic feet into board feet when desired.

The field work. Probably the best results will be obtained conducting the field work about as follows. On any particular area, first find the frustum form factor or absolute diameter breast high cylinder form factor. This must be done first because if the ratio of top diameter to diameter breast high (taper ratio) and form factor are uniform over a given type, the estimate can be based on the type as a unit of area; on the other hand if it is determined that there are several different taper ratios and form classes in the same type, it will be necessary to base the estimate on form classes rather than type areas and tally the trees by these form classes.

There are several ways of obtaining this local taper and form data which may be available under different conditions. If felling is in progress on sites exactly similar to the ones to be estimated, a few well distributed trees can be measured as felled. If no felling is in

progress, the use of a dendrometer becomes necessary in order to get these measurements. The necessary measurements are:

(a) Diameter outside bark (d. o. b.) at merchantable height.

(b) Diameter outside bark at one-half distance between diameter breast high and merchantable height.

(c) Diameter breast high.

(d) Height. It is unnecessary to take height in order to obtain f. f., but it can be done most easily at this time.

From these measurements r (the taper ratio) and q_2 (form quotient) can be computed.

$$r = \frac{d}{\text{d. b. h.}} \qquad q_2 = \frac{d_2 - d}{\text{d. b. h.} - d.}$$

In which d = top diameter

d_2 = diameter half way between diameter breast high and top. (See plate IV).

Since the error arising from using the absolute diameter breast high cylinder form factor applied to a full length cylinder is largely compensated for by ignoring the correction for formula I, the cylinder form factor can be computed directly by formula IV. (See appendix).

A more exact value for the cylinder form factor can be obtained first by computing the frustum form factor, correcting it by its progression and then converting it to the cylinder form factor by formula III (see appendix).

The continual use of the dendrometer will be necessary until a man has trained his eye to estimate diameters accurately. Probably it never can be entirely dispensed with as the eye needs continual checking to insure accurate work. Clark has described in the Forest Quarterly (6) the dendrometer which he has used to train the eyes of his estimators.

After obtaining the form factor, the tallying of the trees may be done as usual, except as noted above.

The mill factor should be obtained locally by mill scale studies. If this is impossible the estimator must use his judgment in applying general mill factors to local timber. Schenck in his "Cruiser's Table" used mill factors 5, 6, 7, and 8 (the number of board feet in one cubic foot).

Computing estimate. The steps in computing the estimate are as follows:

(a) Draw a separate height curve for each type or form class on the basis of diameter in the usual way.

(b) Pick out of the general table of cylinder volume the volumes corresponding to the heights shown by the height curve (see appendix for tables).

(c) Apply the cylinder form factor computed in the field to these volumes. This will give the volume in cubic feet. It may be converted into cords in the usual way or into board feet by use of the mill factor determined in the field.

The system of timber estimating just outlined to many readers will appear to be needlessly complicated. Former systems have sacrificed accuracy to simplicity. The proposed plan, like a green colt, needs to be used and, in proportion to its use, will be better understood and found the more serviceable.

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X. APPENDIX

1. KEY TO SYMBOLS USED IN FORMULAS

Vt—Volume of tree.
Vf—Volume of frustum of cone.
Vc—Volume of cylinder.
D—Diameter breast high (d. b. h.).
d—Diameter at top merchantable height, outside bark.
d_2—Diameter half way between d. b. h. and top.
h_1—Height above diameter breast high.
h_2—Length section below diameter breast high.
h—Total merchantable height.
f. f.—Frustum form factor.
c. f.—Cylinder form factor.
e—Ratio in geometrical progression.
l—Last term geometrical progression.
r—Taper ratio.

2. FORMULAS I-IV

Formula I. To find value of the absolute diameter breast high frustum form factor (f. f.) in terms of the taper ratio (r) and form quotient (q_2).

The general equation for the volume of the frustum of the neiloid, paraboloid and cone is:

$$V = \frac{\pi h}{6}\left(\frac{D^2}{4} + \frac{d^2}{4} + \frac{4d^2}{4^2}\right) \qquad (1)$$

$$\text{f. f.} = \frac{V_t}{V_f} \qquad \text{By definition} \quad (2)$$

Expressing (2) in terms of (1)

$$\text{f. f.} = \frac{D^2 + d^2 + 4d_2^2}{D^2 + d^2 + (D+d)^2} \qquad (3)$$

$$d = Dr \qquad \text{By definition} \quad (4)$$

$$q_2 = \frac{d_2 - d}{D - d} \qquad \text{By definition}$$

$$\therefore d_2 = q_2(D - d) + d \qquad (5)$$

Substituting (4) and (5) in (3)

$$\text{f. f.} = \frac{1 + r^2 + 4(q_2 - q_2 r + r)^2}{2(1 + r + r^2)}$$

TO DETERMINE CORRECTION FOR FORMULA I

Plate VII shows that when formula I is solved for a fixed f. f. value the resulting curve lies below the empirical curve for the same fixed value. If the values for r and q_2 are read from the empirical curve the resulting values for f. f. are as follows:

Value from 0.850 empirical f. f. curve		f. f. Value Formula I	Values from 0.950 empirical f. f. curve		f. f. Values Formula I
r	q_2		r	q_2	
0.600	0.322	0.886	0.650	0.419	0.956
0.700	0.244	0.886	0.700	0.403	0.956
0.750	0.188	0.887	0.750	0.375	0.954
.....	.....	.....	0.800	0.342	0.954
.....	.....	.....	0.900	0.206	0.955

Thus when empirical (actual tree values) are used in formula I the results are too high by practically a constant difference for a given f. f. value. This difference increases as the f. f. value departs from unity and suggests that it may be a function of the difference between f. f. and unity. After several attempts were made at an empirical expression for this variation its similarity to a geometrical progression in which the following relations obtained was observed:

a (1st term) = amount to be added to f. f. value of unity by formula I to obtain empirical value.

n (number of terms) = difference between unity and f. f. value by formula I $\times$ 100 + 1. For example:

f. f. = 1.00 Variation = 1st term
f. f. = 0.99 Variation = 2nd term
f. f. = 0.98 Variation = 3rd term

---

f. f. = 0.88 Variation = 13th term

e = ratio of progression.

1 = (last term) = variation usually being sought. Since the data were not sufficient to draw the empirical curve for unity accurately, both (a) and (e) are unknown. Temporarily, therefore, let a = variation for 0.955 f. f. value, making

$$a = 0.955 - 0.950 = 0.005.$$

Also let 1 = variation for 0.886 f. f. value which corresponds to an 0.850 empirical value making

$$1 = 0.036$$

$$n = (0.955 - 0.886)100 + 1 = 7.9$$

$$e = \sqrt[n-1]{\frac{1}{a}} \qquad \text{(standard formula)}$$

$$= \sqrt[6.9]{\frac{.036}{.005}} = 1.337 = 1.34$$

Using e = 1.34 (a) can be found. Let

$$1 = \text{variation on } 0.886 \text{ f. f. value} = 0.036$$

$$n = (1.00 - 0.866)100 + 1 = 12.4$$

$$a = \frac{1}{e^{n-1}} \qquad \text{(standard formula)}$$

$$a = \frac{0.036}{1.34^{11.4}} = 0.00128 = 0.0013$$

Two points do not determine a geometrical progression and, therefore, the above computation is in no way a proof. It is accepted and used in this connection because it worked better than any purely empirical expression which could be found. The following table shows that formulas I, corrected by this progression, will compute the frustum form factor within less than 1% error when the empirical value is made up of enough trees to afford a fair average. The maximum percent of error on individual trees was found to be ± 10%. (See following table).

No. Trees	r	q_2	Empirical f. f.	f. f. by Formula I Corrected	% error
64	0.702	0.291	0.899	0.904	0.6
40	0.703	0.250	0.855	0.858	0.4
78	0.748	0.271	0.894	0.901	0.8
44	0.797	0.225	0.906	0.908	0.2
31	0.645	0.348	0.901	0.902	0.1
12	0.606	0.407	0.946	0.935	—1.2
15	0.792	0.162	0.862	0.876	1.6

Formula II. To find value of the absolute diameter breast high cylinder form factor (c. f.) in terms of the frustum form factor (f. f.) and taper ratio (r).

$$\text{c. f.} = \frac{Vt}{Vc} \qquad \text{By definition}$$

$$= \frac{Vf \times \text{f. f.}}{Vc} \qquad (1)$$

$$Vf = \frac{\pi h_1 (D^2 + d^2 + Dd)}{12} \qquad \text{Standard formula (2)}$$

$$Vc = \frac{\pi D^2 h_1}{4} \qquad \text{Standard formula (3)}$$

Substituting (2) and (3) in (1)

$$\text{c. f.} = \frac{\pi h (D^2 + d^2 + Dd)\,\text{f. f.}}{12} \times \frac{4}{\pi D^2 h} \qquad (4)$$

$$d = D\,r \qquad \text{By definition (5)}$$

Substituting (5) in (4) and reducing

$$\text{c. f.} = \frac{(1 + r + r^2)\,\text{f. f.}}{3}$$

Formula III. To find value of the cylinder form factor, when section below diameter breast high is computed as a cylinder, in terms of the absolute diameter breast high frustum form factor and taper ratio.

$$\text{c. f.} = \frac{Vt}{V} \qquad \text{By definition}$$

$$= \frac{[Vf\ (\text{above d. b. h.})\,\text{f. f.}] + V\ (\text{below d. b. h.})}{Vc} \qquad (1)$$

Expressing Vf and Vc in terms of standard formulas as in formula II:

$$\text{c. f.} = \left[\frac{\pi h, \text{f. f.} (D^2 + d^2 + D\,d)}{12} + \frac{\pi D^2 h_2}{4} \right] \frac{4}{\pi D^2 h} \qquad (2)$$

$$d = D\,r \qquad \text{By definition (3)}$$

Substituting (3) in (2) and reducing

$$\text{c. f.} = \frac{h_1 \times \text{f. f.}\ (1 + r + r^2) + 3h_2}{3h}$$

Formula IV. To find value of absolute diameter breast high cylinder form factor in terms of form quotient and taper ratio.

$$\text{c. f.} = \frac{Vt}{Vc} \qquad \text{By definition (1)}$$

$$Vt = \frac{\pi . h_1}{6}\left(\frac{D^2}{4} + \frac{d^2}{4} + \frac{4d_2^2}{4}\right) \qquad \text{Standard formula (2)}$$

$$Vc = \frac{\pi\, h_1\, D^2}{4} \qquad \text{Standard formula (3)}$$

$$d = D\, r \qquad \text{By definition (4)}$$

$$d_2 = q_2\, D - q_2\, D\, r + D\, r \qquad \text{By definition (5)}$$

Substituting (2), (3), (4) and (5) in (1) and reducing

$$\text{c. f.} = \frac{1 + r^2 + 4(q_2 - q_2 r + r)^2}{6}$$

3. Concerning Tabular Matter

There are on hand in a fire-proof safe in Morrill Hall at this institution, a series of tables, four in number, which have relationship to the matter published in this bulletin. They are so voluminous that it seems impracticable to print them. They will be shown to any person desiring to consult them or will be sent by registered mail or insured express at the expense of any person who desires to review them, to be returned in similar fashion. Correspondence should be had with the Director of the Station.

Table I. Showing average absolute diameter breast high frustum form factors (f. f.) and taper ratio (r) grouped by species and diameter breast high and clear height classes, together with the range in value in each average; for Yellow Birch, and for Hard Maple.

Table II. Volume table cylinders cubic feet with bark allowance; for Yellow Birch.

Table III. Volume table cylinders cubic feet with bark allowance; for Hard Maple.

Table IV. Volume table cylinders cubic feet outside bark (copied from Schlich, William, A Manual of Forestry, Appendix D, Table III, Bradbury. Agnew & Co., London, 1895).

MAY, 1918 BULLETIN 211

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

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THE AERIAL FERTILIZATION OF PLANTS WITH CARBON DIOXID

M. B. CUMMINGS AND C. H. JONES

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EXCHANG
MICHIGAN STATE College
MAR 22 '4^

BULLETIN 211: THE AERIAL FERTILIZATION OF PLANTS WITH CARBON DIOXID

By M. B. Cummings and C. H. Jones

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I. SUMMARY

Carbon dioxid (carbonic acid gas) is a natural food for plants. It occurs in minute quantities in the air, enters the plant through the stomates (breathing pores) and is utilized in the manufacture of starch. Normal air contains about three parts by volume and approximately two parts by weight in 10,000. So much is used in plant nutrition and tissue construction that it seemed possible that if more than the normal air content of carbon dioxid were supplied, plant growth might be increased. Consequently trials were instituted with a view of determining the facts.

The trials were begun in 1909 and continued for seven years. The earlier years were spent in learning how to go to work and no use has been made of the data secured before 1911. Widely dissimilar types of plants were chosen in order to afford an opportunity to study the nature of the response of different plant structures, beans and peas representing the legumes, radishes and potatoes the root and tuber crops, lettuce, Swiss chard and endive the foliage plants of the salad class, the strawberry of the fruit crops, and nasturtiums (Tropaeolum) and cyclamen the flowering plants.

The writer was unable to devise any satisfactory method whereby an accurate test could be made of the ability of plants grown in closed receptacles to use carbon dioxid in excess which did not subject them to abnormal conditions of humidity and ventilation. Consequently open cases were employed in all of the trials discussed in this article. The carbon dioxid was generated continuously, liberated slowly and allowed to bathe the plants by dispersion.

Legumes. The early effect of an extra carbon dioxid dosage on beans was to stimulate the growth of the seedlings, thus producing larger plants, the later effect was to enhance the production of pods and beans and slightly to change the chemical composition of the plant by proportionately increasing the carbohydrate storage. Peas similarly benefited through exposure to air surcharged with carbon dioxid. The foliage was more abundant, the stalks longer and heavier and the seed yield much greater.

Root and tuber crops. Radishes responded less favorably than did most of the plants used in these trials. The results were positive in all instances but the degrees of benefit were variable.

NOTE—The authors express their obligation to Stanley Hargreaves, former Station gardener, for constant and painstaking care of the experimental crops.

Weight increments were distributed in roots and stems but chiefly the former were affected. The treated plants grew faster than the untreated ones, became edible sooner and they exhibited larger carbohydrate and smaller protein contents.

Potatoes, as a rule, grew more leaflets and more, heavier and better tubers when dosed with carbon dioxid. Tuber formation did not begin earlier but proceeded faster when once started. However, in about one-fifth of the instances the untreated plants weighed less than did the treated ones.

Foliage crops. Swiss chard and endive responded to gas treatment by producing larger and heavier foliage and by maturing earlier, whereas the trials with lettuce were somewhat inconclusive, although in a majority of instances the treatment seemed beneficial.

Fruits. Strawberry plants were decidedly benefited by the treatment. Their foliage was more abundant and heavier and the total weight and number of fruits far in excess of the production of untreated plants.

Flowers. Cyclamens either yielded more flowers or showed gains in weight of corms when extra carbon dioxid was furnished. Nasturtiums grown in gas-laden air gained consistently as compared with untreated plants. The flowers blossemed earlier, were produced in greater profusion and the total weight of the plants as well as the number and weight of the leaves were increased.

Excessive carbon dioxid dosage in general stimulates plant growth and consequently increases production, both of total crop weight and of food nutrients. It appears to function much as does a commercial fertilizer, to be to a greater or less extent a limiting factor in plant growth. Plants can use advantageously more than normally occurs in the air.

The chemical composition of plant life is slightly though not materially changed by the stimulation of carbon dioxid. The treated plants almost without exception show higher carbohydrate and lower protein contents than do those grown under normal conditions. The differences seldom exceed two or three percent and often are less than this. Beans are affected thus primarily in their leaf, stem and pod growth and less noticeably in their seed.

The optimum amount of carbon dioxid for use in open boxes where dispersion is continuous appears determined in the main by the plant which is under trial. Lettuce seemed to stand and profit by a daily bath in nearly 300 liters of carbon dioxid. Continuity of supply seems to be quite as important as its gross amount.

II. INTRODUCTION

When growing crops one always aims, consciously or unconsciously, to improve their soil habitat. If there is too much water, drainage is resorted to; if too little, irrigation may be employed; if available plant food is lacking, manures and fertilizers are used. In the greenhouse, cool rooms are warmed and ample light supplied, even to the extent sometimes of using electricity or acetylene during the short winter days. In each case the aim is to secure as nearly as may be uniform optimum conditions of plant growth in order that no untoward condition may act as a limiting factor.

Plant physiologists have long recognized two distinct sources of food, namely, the soil and the air. The soil-derived elements entering the roots in soluble forms are in the main nitrogen, potassium, phosphorus, calcium, magnesium, iron, sodium, chlorin, sulphur and silicon. The air elements include nitrogen (indirectly through the soil), oxygen and hydrogen (indirectly via the soil water) and carbon as dioxid (carbonic acid gas). This latter named gas is a normal, natural food for green plants which is assimilated in minute quantities at any given time but in immense quantities in the aggregate. It enters the plant structure through the stomates or breathing pores which occur in great abundance in the epidermis of most plants, being utilized in the manufacture of such carbohydrates as cellulose, starch and sugar. Indeed approximately one-half the dry matter of plant structure is composed of carbon.

Air contains about three parts carbon dioxid by volume and two parts by weight in 10,000. It contains so little—relatively speaking, though absolutely there is much—and plant life uses such stupendous quantities, that the question arose in the writer's mind whether the carbon dioxid content of normal air might not be artificially increased and crops be thus aerially fertilized. He is not the first or only person to speculate upon this matter or to inaugurate experimental trials, as the references cited herewith will attest, although the subject was discussed and preliminary plans were outlined by him with an associate at another institution in 1905. The earlier tentative trials upon which this article is based were begun in 1909, two years before the appearance of Fischer's paper which is referred to elsewhere.

Earlier Work

Apparently the use of carbon dioxid as a means of plant forcing has not been investigated in this country. However, certain phases

of the subject have been studied in England, Germany and France. Demousy[1] grew lettuce in belljars and found that plants given five times the normal amount of carbon dioxid increased in weight in a 40-day test. Brown and Escombe[2] grew plants in small glass-house structures, the air of one of which was enriched with carbon dioxid. While certain physical changes, such as reduced leaf areas and shortened internodes, were effected and the reproductive functions were much disturbed, no increment in dry matter production resulted. They concluded that plants already were tuned to the conditions of the normal carbon dioxid content of the air. Farmer and Chandler[3] made microscopic studies of plants grown in an atmosphere surcharged with carbon dioxid and reported that the mesophyll of the leaves was somewhat more spongy, the vascular bundles less well developed, the number of stomates increased and that the leaves carried a larger starch content. Fischer[4] experimented with Selaginella, Coreopsis and Tropaeolum and reported greater dry weights and increased profusion of blossoming following a considerable gas dosage and forecasted commercial opportunities. Kresler[5] tested the influence of extra amounts of carbon dioxid by attaching an apparatus to leaf sprays, using electric light in place of sunlight. He stated that the amount of gas used was in proportion to its pressure and to the light intensity. He found an increased usage by the plant roughly proportionate to the increment in the amount of gas present from the normal supply up to a one percent content and believed, but did not prove, that the optimum amount lies between one and ten percents. Chapin[6] conducted laboratory tests on seedlings and with certain fungi and reported that the optimum for seedbearing plants lies between one and two percents. He also stated that an atmosphere of 60 percent carbon dioxid will prevent the germination of the spores of Mucor and that one of 100 percent is required to inhibit the germination of the spores of Penicillium and Aspergillus.

THE PRESENT STUDY

As a matter of fact there has been thus far but little consideration given to the principles of response among horticultural plants under the influence of unusual amounts of carbon dioxid. The present inquiry

[1] Le Jardin, No. 18, p. 221 (1904).
[2] Proc. Royal Soc. London, Vol. 70, pp. 397-413 (1902).
[3] Proc. Royal Soc. London, Vol. 70, pp. 413-423 (1902).
[4] Zeitschrift fur Garten-und Blumenkunde, 60, pp. 298-307 (1912).
[5] Landwirthschaftliche Jahrbucher, 14, pp. 913-965 (1885).
[6] Flora oder Allgem. Bot. Zeitmog Erganqungsbrand, 91, pp. 348-379 (1902).

attempted to determine the general behavior of greenhouse plants aerially supplied with inordinate quantities; to ascertain its various effects on the size, quality, flowering and fruiting habits of treated plants; to make seasonal applications with a view of learning at what time of year its application is most serviceable; to determine the optimum dosage most conducive to plant advancement; and, finally, to observe what modifications in composition, if any, the plants undergo when thus treated.

EXPERIMENTAL DETAILS

Culture boxes. Many sorts and sizes of boxes and other receptacles were used in the preliminary trials. Considerable difficulty was experienced in determining the proper structure. Finally two sizes and shapes of boxes made of wood and glass were adopted. The plants other than the lettuce were grown in boxes 26″ (depth) x 26″ x 18″. Lettuce was grown in shallow boxes, the back and frames being made of wood, the front and two sides of glass. The boxes used for small stature plants, such as radishes and lettuce, were shaped much like hotbed frames, the dimensions being 52″ x 28″ x 12″, glass being used to admit light to the enclosed plants. The boxes were open at the top both day and night, a condition which experience dictated as a necessity in providing suitable conditions of humidity and in properly controlling the temperature about the experimental plants. The use of air-tight boxes or belljars introduced difficulties at the very start, produced abnormal conditions and ultimately led to disaster. A large amount of work was done in so-called "closed boxes," the results of which have been thrown into the discard as generally unreliable. One always felt doubtful as to the validity of the results; indeed, sometimes they were utterly discordant. However, this much of positive gain has been secured from this considerable amount of work, namely, a perfect definite knowledge that closed boxes are impossible. Obviously the cultural conditions of the trial plants, other than the one varient, the atmospheric content of carbon dioxid, must be normal throughout the trial if the soundness of the outcome of the trials is to be assured.

Providing the gas. Sodium bicarbonate and sulphuric acid were used. Few if any injurious fumes were evolved from these relatively pure materials. Definite quantities of the bicarbonate were dissolved in warm water and the acid, diluted with 16 volumes of water, conveyed drop by drop into it by means of glass tubing, pinchcocks and a syphon mechanism. The carbon dioxid slowly, evenly, continuously

evolved, was carried to the central portion of the culture boxes, where it was allowed to diffuse about the plants, thus bathing them continuously throughout the daylight hours. Figure 4 supplements this description and may afford a clearer idea of the generating apparatus and general equipment.

Choice of plants. Widely dissimilar plants, quite unlike in chemical composition, in the manner of their growth and in the nature of their edible parts, were chosen in order to afford an opportunity more fully to observe and better to understand the nature of the response to carbon-dioxid nutrition. The list embraced peas and beans (legumes); radishes and potatoes (root and tuber crops); lettuce, endive and Swiss chard (edible foliage); and cyclamens, nasturtiums and strawberries (flowers and fruit). It was believed that a study of the behavior of plants so decidedly unlike as to their nature and manner of growth, living in an atmosphere enriched with carbon dioxid, would be likely to forecast the response of other plants of similar characteristics and would furnish sufficiently reliable information so that one might hazard an attempt at a statement of principles.

III. INFLUENCE ON LEGUMES

Peas and beans were chosen for the reason that they possess a relatively large number of structural units with which to make comparisons.

1. BEANS

The bean plant was considered specially suitable for several reasons. It presents many features which enable careful comparison of the effect of the gas on different parts of the plant; its stem structure, including distinct nodes and internodes, hypocotyl and epicotyl, its definite method of fructification, its thin flat leaves, flowers, pods and seeds. It is a warm temperature plant and may be grown in the greenhouse in the summer as well as in the winter. It is a starch-storing as well as a starch-forming plant. And, finally, its blossoms are self-fertilizing, so that the number of seeds that are set is not left to the chance visits of insects.

The experiments with beans were continued throughout the entire year and for several years, thus affording an opportunity to note the effects of climatic influence in connection with this special method of nutrition. In view of the fundamental relationship of the amount of

sunshine to carbon assimilation, it naturally was assumed that this factor was of much importance, and, therefore, it was thought desirable to record any correlations or interrelations of climate and superabundant carbon dioxid usage.

The gas was supplied as soon as the plants had completed germination and in considerable quantities for eight hours daily. This period was found to be the maximum necessary during the winter months and was adopted for use throughout the entire year. Ten separate plantings were made. A few plants in each trial were harvested at each of several different stages of growth. None of them were allowed to come to maturity during the first five trials. The object of premature cuttings was to enable the writer to make physical analyses of the plants in order to determine the effects of the carbon dioxid dosages on the immature plant structure. In the last five trials the plants were allowed to grow until the foliage began to discolor but were harvested before the leaves began to drop. With scarcely an exception the treated and untreated plants matured evenly and at approximately the same dates.

(*a*) PHYSICAL ANALYSES

In view of the fact that gas dosage affects the plant both physically and chemically, each phase needs separate presentation.

	Plants: number	Plants: green weight gram	Leaves: green weight gram	Stem: length cm.	Hypocotyl: length cm.	Epicotyl: length cm.	Petiole: length cm.	Leaf surface area: total sq. cm.
		(1) December 27, 1912-January 8, 1913. 12 days, 29 percent sunshine.						
Gas	4	27.5	13	13.8	6.1	5.1	4.07	75.2
Check	4	21	10.2	12.8	5.1	4.6	4.17	66.1
Gas ± Check	..	+ 6.5	+ 2.8	+1	+ 1	+ 0.5	—0.1	+ 9.1
Gas ± Check %	..	+31	+27.3	+7.3	+18.2	+12.1	—2.5	+13.9
		(2) December 27, 1912-January 15, 1913. 19 days, 37 percent sunshine.						
Gas	4	30.2	16.8	19.7	6.2	5.3	4.77	99.5
Check	4	24.8	13.9	13.5	4.5	4.1	4.35	85.8
Gas ± Check	..	+ 5.4	+ 2.9	+ 6.2	+ 1.7	+ 1.2	+0.42	+13.7
Gas ± Check %	..	+21.8	+20.8	+45.9	+37.8	+29.3	+9.7	+16
		(5) January 1-March 8, 1913. 66 days, 40 percent sunshine.						
		1	2	3	4			
Gas	8	362	45	41	44.5			
Check	8	230	33	36.5	47.5			
Gas ± Check	..	+132	+12	+ 4.5	—3			
Gas ± Check %	..	+57.4	+36.9	+12.9	—6.8			

Headings for trial 5, (1) number of leaves, (2), (3), (4), respective lengths in c. m. of first, second and third internodes.

	Plants: number	Plants: green weight gr.	Leaves: number	Leaves: green weight gr.	Pods: number	Pods with beans: green weight gr.	Pods with beans: number	Pods with beans: green weight gr.	Beans: number	Beans: green weight gr.	Stems: green weight gr.
		(3) November 1-December 6, 1912. 36 days, 27 percent sunshine.									
Gas	4	348	230	210	35	19		Harvested while immature			
Check	4	302	214	192	32	15		Harvested while immature			
Gas ± Check	..	+46	+16	+18	+3	+ 4					
Gas ± Check %	..	+15.3	+ 7.5	+ 9.4	+9.4	+24					
		(4) November 1-December 13, 1912. 42 days, 31 percent sunshine.									
Gas	4	443	241	217	50	121		Harvested while immature			
Check	4	356	223	197	45	52		Harvested while immature			
Gas ± Check	..	+87	+18	+20	+ 5	+ 69					
Gas ± Check %	..	+24.4	+ 8.1	+10.2	+11.1	+132.7					

TABLE I. BEANS: PHYSICAL ANALYSES—*continued*

	Plants: number	Plants: green weight gr.	Leaves: number	Leaves: green weight gr.	Pods: number	Pods with beans: green weight gr.	Pods with beans: number	Pods with beans: green weight gr.	Beans: number	Beans: green weight gr.	Stems: green weight gr.
(6) April 10-July 2, 1913. 82 days, 55 percent sunshine.											
Gas	18	2642	604	517	214	1317	202	1307	700	730	808
Check	18	1368	719	392	164	566	130	552	434	342	410
Gas ± Check.....	..	+1274	—115	+125	+50	+751	+72	+755	+266	+388	+398
Gas ± Check %..	..	+ 93.1	— 16	+ 31.9	+30.5	+132.8	+55.4	+136.9	+ 61.3	+113.7	+ 97.2
(7) July 25-October 23, 1913. 91 days, 58 percent sunshine.											
Gas	11	1784	892	481	101	672	88	660	295	381	631
Check	11	985	847	263	55	368	44	352	139	179	354
Gas ± Check.....	..	+799	+45	+218	+46	+304	+ 44	+308	+156	+202	+277
Gas ± Check %..	..	+ 81.1	+ 5.3	+ 82.9	+83.6	+ 82.6	+100	+ 87.5	+112.6	+112.9	+ 78.3
(8) January 24-May 3, 1913. 99 days, 41 percent sunshine.											
Gas	8	1280	709	573	120	369	72	...	100	144	338
Check	8	979	655	528	57	234	37	...	42	62	219
Gas ± Check.....	..	+301	+54	+45	+ 63	+135	+35	...	+ 58	+ 72	+119
Gas ± Check %..	..	+ 30.7	+ 8.2	+ 8.6	+110.4	+ 57.7	+94.6	...	+138.1	+116.2	+ 54.4
(9) April 25-June 26, 1913. 62 days, 55 percent sunshine.											
Gas	29	2307	668	525	211	1341	174	1320	550	598	441
Check	29	2195	659	579	191	1234	152	1213	499	533	382
Gas ± Check.....	..	+112	+9	—54	+20	+107	+22	+107	+51	+65	+59
Gas ± Check %..	..	+ 5.1	+1.4	— 9.2	+10.5	+ 8.7	+14.5	+ 8.8	+10.2	+12.3	+13.5
(10) May 1-July 5, 1913. 66 days, 52 percent sunshine.											
Gas	22	*	529	*	186	681	158	672	671	349	241
Check	22	*	337	*	172	423	124	417	464	191	222
Gas ± Check.....	..	..	+192	..	+14	+258	+34	+255	+207	+158	+19
Gas ± Check %..	..	..	+ 57	..	+ 8.1	+ 61	+27.4	+ 61.1	+ 44.6	+ 82.7	+ 8.6

*Leaves dried and dropped off. Dry matter weights, 876 and 873 grams respectively.

The first trial lasted only 12 days. For a week or more no apparent differences were observed between the gas-fed plants and the checks, but at the expiration of the 12-day period slight variations began to appear which were found to be distributed over the several organs of the bean plants. The gas-fed plants were superior to the checks in exhibiting a greater total weight, greater leaf weight, a longer stem, a longer hypocotyl and epicotyl, and a greater leaf area. Similar results were secured in a second trial which was continued for 19 days.

When growth was continued for 36 days additional structures became available for study. The number of leaves and the number and weight of pods were greater on the gassed plants than on the checks. A similar outcome was in the main secured in two further trials, lasting 42 and 66 days respectively. The plants were allowed to grow for 82 days and to come to full maturity in the sixth trial and the check plots and those treated with gas were rendered comparable on the basis of fruitage. In this instance the gassed plants carried more pods of a greater total weight and more beans of a greater weight. Similar results were secured in further trials in which the plants grew to the fruitage period, so that the actual production capabilities of checks and gas-fed plants could be compared. The gains varied somewhat, but in every instance the gassed plants outstripped the normally grown checks.

The carbon dioxid seemed to exert distinct effects on the several parts of the bean plant. Their total green weights were in all cases greater, the gains ranging in the five trials wherein the crop grew to maturity from 5 to 93 percent. In one such instance the gassed plants grew so much more luxuriantly than their mates that the leaves on the checks dried first and dropped, thus making comparisons on this basis quite futile. No total weight data were taken in trial 5 which was devoted to the determination of another point.

Clearly superabundance of carbon dioxid tended to develop a larger plant structure. The treated plants in several instances carried more leaves than the untreated ones, the increase varying from one to 57 percent and averaging 16 percent. In one trial (Table I, 6) the exception proved the rule, the gassed plants carrying 16 percent less number of leaves than the check crop. No leaf counts were made in trials 1 and 2. The leaf surface areas were determined in the first four trials with positive results in the first three and negative in the fourth instance, the gains for the three lots of gassed plants averaging 16 percent. The individual leaves were larger on the gassed than on

the check plants. No leaf surface area determinations were attempted in trials 5 to 10 on account of the curling of the foliage.

The length of such internodal structures as hypocotyl and epicotyl are relatively unimportant items, yet it may be remarked that the gas-treated plants outclassed their mates in this respect (Table I, 1, 2).

The treated plants invariably produced more beans than the untreated ones in the five trials in which they were allowed to mature. The number increases varied from 10 to 138 percent, averaging 73 percent, whereas the weight increases varied from 12 to 116 percent, averaging 88 percent. The differences as between the several lots are very great and the reasons for such variations are obscure. However, the small increases, 10 and 12 percents in trial 9, may be attributed to the congested condition of the boxes. Twenty-nine bean plants, grown in three and one-half square feet, were much more of a crowd than the traditional three. The soil was too full of roots and the tops unduly shaded each other. A similar but less acute situation obtained in trial 10 where the weight gain was 83 percent.

(*b*) CHEMICAL ANALYSES

Chemical analyses were made of nine gassed and check crops. In five instances the crop was analysed as a whole, and in four the various separates, seed, pods, stems (including petioles) and leaves were analysed, and the composition of the entire plant was computed from the analyses of the several separates.

The following statement is also expressed in terms of weight of the constituents which serves still more clearly to set forth the nature of the outcome.

		Plants: number	Green weight	Dry matter	Dry matter weight	100 parts dry matter contained: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
			grams	%	grams	%	%	%	1:	grams	grams	grams
1	Gas	4	27.5	7.63	2.1	15.99	20.92	63.09	3.01	...	...	...
	Check	4	21	7.81	1.6	12.76		Sample too small to be analyzed				
	Gas ± Check %		+31		+28							
2	Gas	4	30.2	9.87	3	15.22	19.29	65.49	3.39	...	...	...
	Check	4	24.8	9.88	2.5	14.52	19.04	66.44	3.47	...	...	...
	Gas ± Check %		+21.8		+21.6							
3	Gas	4	348	15.92	55.3	13.12	23.25	63.63	2.74	7.2	12.9	35.2
	Check	4	302	14.76	44.5	14.36	24.68	60.96	2.47	6.4	11	27.1
	Gas ± Check %		+15.2		+24.3					+12.5	+17.3	+29.9
4	Gas	4	443	14.30	63.3	13.42	22.89	63.69	2.78	8.5	14.5	40.3
	Check	4	356	14.86	52.9	13.75	23.28	62.97	2.70	7.3	12.3	33.3
	Gas ± Check %		+24.4		+19.7					+16.4	+17.9	+21
5	Gas	No analyses made, only lineal measurement data being taken—see table.										
	Check											
6	Gas	18	2642	31.41	829.9	12.74	13.75	73.52	5.35	105.7	114.1	610.1
	Check	18	1368	50.42	689.7	27.83	14.29	57.88	4.05	192	98.5	399.2
	Gas ± Check %		+93		+20.3					—44.9	+15.8	+52.9
7	Gas	11	1784	29.56	527.5	15.14	17.30	67.56	3.91	79.8	91.3	356.4
	Check	11	985	28.25	278.2	17.07	18.07	64.86	3.58	47.4	50.3	180.5
	Gas ± Check %		+81.1		+89.6					+67.9	+81.5	+97.4
8	Gas	8	1280	25.45	325.8	13.32	19.81	66.87	3.38	43.4	64.6	217.8
	Check	8	979	21.25	208	13.69	21.00	65.31	3.11	28.4	43.7	135.9
	Gas ± Check %		+30.8		+56.6					+52.8	+47.8	+60.3
9	Gas	29	2307	22.62	521.5	9.98	14.28	72.74	5.31	52	74.5	395
	Check	29	2195	21.72	476.7	5.80	15.80	78.40	4.96	27.6	75.3	373.8
	Gas ± Check %		+5.1		+9.4					+88.4	—1.1	+5.7
10	Gas	22	*	*	392	16.89	15.84	67.27	4.25	66.2	61.9	263.9
	Check	22	*	*	237.3	26.63	17.15	56.22	3.28	63.2	40.7	133.4
	Gas ± Check %				+65.2					+4.7	+52.1	+97.8

*Leaf weights lost.

TABLE II. BEANS: ENTIRE PLANT AND SEPARATES; CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS—*continued*

		Plants: number	Green weight	Dry matter	Dry matter weight	100 parts dry matter contained			Ratio			
						Crude ash	Crude protein	Carbohydrates and ether extract		Crude ash	Crude protein	Carbohydrates and ether extract
			grams	%	grams	%	%	%	1:	grams	grams	grams
					Seed							
6	Gas	18	730	44.77	326.7	5.64	24.36	70.00	2.9	18.4	79.7	228.6
	Check	18	342	72.00	246.2	5.88	27.85	66.27	2.4	14.5	68.5	163.2
	Gas ± Check %		+113.7		+32.7					+26.9	+16.3	+16.4
7	Gas	11	381	44.23	168.5	6.07	27.43	66.50	2.4	10.2	46.2	112.1
	Check	11	179	38.42	68.8	5.83	26.26	67.91	2.6	4	18.1	46.7
	Gas ± Check %		+112.9		+144.9					+155	+155.3	+140
8	Gas	8	144	42.22	60.8	6.09	32.25	61.66	1.9	3.7	19.6	37.5
	Check	8	62	32.26	20	5.54	32.80	61.66	1.9	1.1	6.5	12.4
	Gas ± Check %		+132.3		+204					+236.4	+201.6	+202.5
10	Gas	22	397	41.46	164.6	6.04	25.53	68.38	2.7	10	42	112.6
	Check	22	191	37.64	71.9	6.40	29.64	63.96	2.2	4.6	21.3	46
	Gas ± Check %		+107.9		+128.9					+117.4	+97.1	+144.7
					Pods							
6	Gas	18	587	25.04	146.9	9.83	4.29	85.88	20	14.5	6.3	126.1
	Check	18	224	37.59	84.2	10.95	5.10	83.95	16.5	9.2	4.3	70.7
	Gas ± Check %		+162.1		+74.5					+57.6	+46.5	+79.4
7	Gas	11	291	21.65	62.8	11.36	9.91	78.73	7.9	7.1	6.2	49.5
	Check	11	189	13.70	25.9	12.16	10.78	77.06	7.1	3.1	2.8	20
	Gas ± Check %		+51.9		+142.5					+129	+121.5	+147.5
8	Gas	8	225	24.67	55.5	11.11	14.22	74.67	5.3	6.2	7.9	41.4
	Check	8	171	18.36	31.4	8.57	18.09	73.34	4.1	2.7	5.7	23
	Gas ± Check %		+31.6		+76.8					+129.6	+38.6	+80
10	Gas	22	377	17.82	67.2	13.49	6.29	80.22	12.8	9.1	4.3	53.8
	Check	22	232	14.47	33.5	15.30	14.99	69.71	4.7	5.1	5	23.4
	Gas ± Check %		+62.5		+100.7					+78.4	−14	+129.9

TABLE II. BEANS: ENTIRE PLANT AND SEPARATES; CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS—*concluded*

		Plants: number	Green weight	Dry matter	Dry matter weight	100 parts dry matter contained: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
			grams	%	grams	%	%	%	1:	grams	grams	grams
					Stems (including petioles)							
6	Gas	18	808	21.63	174.7	7.86	4.54	87.60	19.3	13.8	7.9	153
	Check	18	410	27.08	111.0	9.54	7.09	83.37	11.8	10.6	7.9	92.5
	Gas ± Check %		+97.1		+58.3					+30.2	0	+65.4
7	Gas	11	631	16.82	106.1	10.47	7.76	81.77	10.6	11.1	8.2	86.8
	Check	11	354	18.76	66.4	12.47	11.23	76.30	6.9	8.3	7.4	50.7
	Gas ± Check %		+78.3		+59.8					+33.7	+10.8	+71.2
8	Gas	8	911	*23.00	209.5	16.00	17.68	66.32	3.8	33.5	37	139
	Check	8	746	*20.97	156.6	15.75	20.08	64.17	3.2	24.6	31.4	100.6
	Gas ± Check %		+22.1		+33.7					+36.2	+17.8	+38.3
10	Gas	22	274	22.12	60.6	10.64	6.18	83.18	13.5	6.4	3.7	50.5
	Check	22	222	20.09	44.6	11.76	11.06	77.18	7	5.3	4.9	34.4
	Gas ± Check %		+23.4		+35.9					+20.8	—24.5	+46.8
					Leaves							
6	Gas	18	517	35.13	181.6	32.53	11.16	56.31	5.0	59.1	20.2	102.3
	Check	18	392	63.29	248.3	63.52	7.18	29.30	4.1	157.7	17.8	72.8
	Gas ± Check %		+31.9		—26.9					—62.4	+13.5	+40.5
7	Gas	11	481	39.53	190.1	27.07	16.06	56.87	3.5	51.4	30.5	108.2
	Check	11	263	44.52	117.1	27.40	18.74	53.86	2.9	32.1	21.8	63.2
	Gas ± Check %		+82.9		+62.4					+60.1	+39.9	+70.4
8	Gas	8	Included in stems—see above.									
	Check	8										
	Gas ± Check %											
10	Gas	22†	...	...	99.6	40.80	12.22	46.98	3.8	40.6	12.2	46.8
	Check	22†	...	...	87.3	55.24	10.82	33.94	3.1	48.2	9.4	29.6
	Gas ± Check %				+15.2					—15.8	+29.8	+58.1

*Stems and leaves together. †Leaf weights not taken.

In order the better to show the relationship existing between the protein and the carbohydrates and fat contents of the several crops, the following table has been constructed, based on the organic dry matter of the entire plants, that is to say, their dry matter contents less their ash constituents. This procedure seemed necessary because in several cases the check plants matured earlier, their foliage dropped and mechanically gathered small quatities of soil, thus making strict comparisons less certain. Care was observed in later trials so far as might be to guard against this complication. However, it is not felt that serious errors exist and such as have crept in are located only in the "leaves" and, because of necessary computations, in the "entire plant" columns.

TABLE III. BEANS: QUALITY OF ORGANIC DRY MATTER

Number	Treatment	Crude protein %	Carbohydrates and ether extract %	Ratio 1:
1	Gas	24.90	75.10	3.01
	Check	Crop sample too small for analysis		
2	Gas	22.75	77.25	3.39
	Check	22.28	77.72	3.49
3	Gas	26.76	73.24	2.74
	Check	28.81	71.19	2.47
4	Gas	26.44	73.56	2.78
	Check	26.99	73.01	2.70
6	Gas	15.75	84.25	5.35
	Check	19.80	80.20	4.05
7	Gas	20.37	79.63	3.91
	Check	21.80	78.20	3.59
8	Gas	22.86	77.14	3.37
	Check	24.33	75.67	3.11
9	Gas	15.86	84.14	5.31
	Check	16.77	83.23	4.96
10	Gas	19.06	80.94	4.26
	Check	23.37	76.63	3.28

In seven of the eight comparisons, the protein contents of the gassed crop were less and the carbohydrate contents more than those of their check mates. The ratios conveniently and concretely set forth this relationship. The one exception—trial 2—was a short time affair (19 days) and opportunity was hardly afforded to show any decided effect.

The gassed plants as compared with the checks:

(*a*) Weighed more in every instance and in every separate.

(*b*) Contained more dry matter in every instance and in every separate, except the leaves in trial 6.

The gains were especially noticeable in the seed. The yield was always more than doubled following gas treatment. In only a single instance did pods or stems show as large a gain as this. The seed grown by the gassed plants were, as a rule, a drier crop than that grown on the check, which perhaps may be interpreted as indicating that more organic matter was packed into a unit of green weight as a result of carbon dioxid dosage. The same situation is noted in connection with the pods, but not with the foliaceous portion of the plant.

There is nothing very outstanding to be noted in the ash percentages although the trend is towards a lower ash content in the entire gassed plant and its several separates than was found when gas was not supplied. The high percentages observed in the check plants in trials 6 and 10 are due primarily to soil particles which became attached to the fallen leaves. Of course the percentages diminish as one passes from the leaf through the stem to the pod and, finally, to the seed.

The protein comparisons are somewhat more significant. In but one of eight comparisons of the entire plant—the short time second trial—and in but three of 15 of the separates did the gassed material contain more protein than the untreated.

The carbohydrate-ether extract data are quite positive. In six of the eight comparisons of the entire plant and 13 of the 15 of the separates, an increased percentages followed the use of the carbon dioxid, and one of the two exceptions among the separates is a tie, and both are located in the seed. The writers feel inclined to think that these may be cause and effect, that the carbohydrate increment is the positive change and the ash-protein decrease a necessary concomitant. Table IV, in which the ash is eliminated, sets forth this situation very clearly. The changes in weight and in the composition of the separates following the carbon dioxid application were shown most decidedly as follows: In dry matter gains, in the seed; in carbohydrate gains, in the leaves.

It seems clear that in these trials an excess of carbon dioxid in the air surrounding the bean plant stimulated it to make larger growth, increased its fruitage and appreciably affected the proportional distribution of its plant constituents, the carbohydrate content being increased.

2. PEAS

The pea plant resembles the bean in presenting several structural features which lend themselves well to the study of the problem in hand. The trials extended over some 16 months. The gas was supplied for eight hours daily in considerable quantities as soon as the plants had thoroughly germinated. Seven plantings were made, five (1-5) with "Premium Gem" and two (6 and 7) with "Witham Wonder." Similar physical and chemical data were taken as when beans were grown. The results are dispayed in the subjoined tables which are constructed on the same plan as those which set forth the results secured with beans.

	Plants: Number	Plants: Weight grams	Leaves: Number	Leaves: Weight grams	Vines: length cm.	Nodes: number	Stems: weight grams	Pods: mature and immature: number	Pods: including contents weight grams	Peas: number	Peas: weight grams
(1) November 4, 1913-January 27, 1914. 85 days, 32 percent sunshine.											
Gas	26	304	1220	106.5	1100	237	78.2	45	119.3	138	51.3
Check	26	283.5	1293	105.6	1019.3	255	97.8	59	80.1	103	28.8
Gas ± Check.....	..	+20.5	—73	+0.9	+80.7	—18	—19.6	—14	+30.2	+35	+22.5
Gas ± Check %..	..	+ 7.2	— 5.7	+0.9	+ 7.9	— 7.1	—20	—23.7	+37.7	+34	+78.1
(2) February 7-April 23, 1914. 75 days, 44 percent sunshine.											
Gas	18	862.8	1478	200.9	902.4	229	135	120	526.9	567	192.2
Check	18	707.4	1350	194.5	1014.3	284	144.5	107	368.4	388	141
Gas ± Check.....	..	+155.4	+128	+16.4	—111.9	—55	—9.5	+13	+158.5	+179	+51.2
Gas ± Check %..	..	+ 22	+ 9.5	+ 8.5	— 11	—19.4	—6.6	+12.1	+ 43	+ 46.1	+36.3
(3) May 23-July 9, 1914. 46 days, 56 percent sunshine.											
Gas	*12	160.8	512	40	283.2	94	22.3	28	98.5	116	50.5
Check	*12	146.2	513	40.5	279.6	94	21.6	25	84.1	99	39.8
Gas ± Check.....	..	+14.6	—1	—0.5	+3.6	0	+0.7	+ 3	+14.4	+17	+10.7
Gas ± Check %..	..	+10	—0.2	—1.2	+1.3	0	+3.2	+12	+17.2	+17.2	+26.9
(4) July 20-September 8, 1914. 50 days, 52 percent sunshine.											
Gas	29	162.5	1014	46.3	562.6	216	23.7	37	92.5	100	53.5
Check	29	141.5	1041	44.8	562.6	228	22.7	35	74	85	41.4
Gas ± Check.....	..	+21	—27	+1.5	0	—12	+1	+2	+18.5	+15	+12.1
Gas ± Check %..	..	+14.8	— 2.6	+3.4	0	— 5.3	+4.4	+5.7	+25	+17.6	+29.2
(5) September 15-November 25, 1914. 71 days, 39 percent sunshine.											
Gas	26	360.3	1170	91	739.7	214	52.6	80	216.7	255	109.6
Check	26	164.2	787	42	459.6	175	24.5	54	97.7	137	41.5
Gas ± Check.....	..	+196.1	+38.3	+ 49	+280.1	+39	+ 28.1	+26	+119	+118	+ 68.1
Gas ± Check %..	..	+119.4	+48.7	+116.7	+ 60.9	+22.3	+114.5	+48.2	+121.8	+ 84.7	+164.1
(6) October 15, 1914-February 8, 1915. 116 days, 33 percent sunshine.											
Gas	33	1233	3932	394.5	2607.5	653	343.5	203	495	633	264
Check	33	582.4	3702	207.8	1950.5	679	184.6	104	190	267	97.7
Gas ± Check.....	..	+650.6	+230	+186.7	+657	—26	+158.9	+99	+305	+366	+166.3
Gas ± Check %..	..	+111.7	+ 6.2	+ 89.8	+ 33.7	— 3.8	+ 86.1	+95.2	+160.6	+137.2	+170.3
(7) November 26, 1914-March 9, 1915. 104 days, 42 percent sunshine.											
Gas	32	1126.7	3351	313.2	2089	605	287.7	201	525.8	824	304.2
Check	32	762.3	3156	271.5	1868.1	618	237.4	95	253.4	426	98.6
Gas ± Check.....	..	+364.4	+195	+41.7	+220.9	—13	+50.3	+106	+272.4	+398	+205.6
Gas ± Check %..	..	+ 47.8	+ 6.2	+15.4	+ 11.8	— 2.1	+21.2	+111.5	+107.5	+ 93.4	208.6

*Plants badly infested with lice, but apparently equally so in both lots.

(*a*) PHYSICAL ANALYSES

The physical data clearly set forth the favorable results secured with carbon dioxid dosage. More green weight was grown by the gassed plants, with one exception, they always grew more pods, they always grew more peas and, with one exception, larger peas. The foliage was usually more abundant and heavier and the stems heavier and larger.

(*b*) CHEMICAL ANALYSES

Chemical analyses were made of lots 4 to 7 inclusive, the last three being analyzed as separates in the same manner as with the beans. The results, together with a statement of the results expressed in terms of weights of the constituents, follow:

TABLE V. PEAS: CHEMICAL ANALYSES; ENTIRE PLANT AND SEPARATES

		Plants: number	Plants: green weight	Plants: dry matter	Plants: dry matter	100 parts dry matter contained: Crude ash	Protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
			grams	%	grams	%	%	%	1:	grams	grams	grams
	(4) July 20-September 8, 1914. 50 days, 52 percent sunshine.											
	Gas	29	162.5	18.95	30.8	11.59	23.37	65.04	2.78	3.6	7.2	20
	Check	29	141.5	18.33	25.9	11.72	23.63	64.64	2.74	3	6.1	16.8
	Gas ± Check %		+14.8		+18.7					+20	+18	+19.1
	(5) September 15-November 25, 1914. 39 days, 71 percent sunshine.											
	Gas	26	360.3	19.77	71.2	9.45	23.39	68.16	3.04	6.7	15.9	48.6
	Check	26	164.4	20.21	32.9	9.77	22.33	67.91	3.04	3.2	7.3	22.4
	Gas ± Check %		+118.3		+116.5					+109	+118	+117
	(6) October 15, 1914-February 8, 1915. 116 days, 33 percent sunshine.											
	Gas	33	1233	18.84	232.3	11.14	20.19	68.67	3.40	25.9	46.9	159.5
	Check	33	582.4	20.00	116.4	11.83	21.05	67.12	3.20	13.7	24.5	78.2
	Gas ± Check %		+111.6		+99.5					+89.7	+91.4	+104
	(7) November 26, 1914-March 9, 1915. 104 days, 42 percent sunshine.											
	Gas	32	1126.7	20.99	236.5	8.74	18.28	72.98	3.99	20.7	43.3	172.5
	Check	32	762.3	17.59	134.1	10.78	21.45	67.77	3.15	14.5	28.8	90.8
	Gas ± Check %		+47.8		+77.9					+42.7	+50.3	+90
	Seed											
5	Gas	..	109.6	27.49	30.1	4.14	27.02	68.84	2.55	1.2	8.1	20.8
	Check	..	41.5	27.33	11.3	3.97	27.14	68.89	2.54	0.4	3.1	7.8
	Gas ± Check %		+164.2		+166.5					+200	+161	+167
6	Gas	..	264	30.63	80.9	4.50	28.24	67.26	2.38	3.6	22.8	54.5
	Check	..	97.7	30.30	29.6	4.50	27.97	67.53	2.42	1.3	8.3	20
	Gas ± Check %		+170.1		+173.3					+177	+174.7	+172.5
7	Gas	..	304.2	28.91	88	4.14	25.58	70.28	2.75	3.6	22.8	61.6
	Check	..	98.6	22.77	22.5	4.79	27.38	67.83	2.48	1.1	6.2	15.2
	Gas ± Check %		+208.5		+291.2					+227	+236.5	+305

TABLE V. PEAS: CHEMICAL ANALYSES; ENTIRE PLANT AND SEPARATES—*continued*

		Plants: number	Plants: green weight	Plants: dry matter	Plants: dry matter	100 parts dry matter contained: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
			grams	%	grams	%	%	%	1:	grams	grams	grams
						Pods						
5	Gas	..	107.1	13.35	14.3	7.90	13.33	78.77	5.92	1.1	1.9	11.3
	Check	..	56.4	14.21	8	8.18	14.13	77.69	5.50	0.7	1.1	6.2
	Gas ± Check %		+89.9		+77.8					+57	+73	+82
6	Gas	..	231	15.06	34.8	9.98	13.49	76.53	5.67	3.5	4.7	26.6
	Check	..	92.3	16.40	15	10.36	17.23	72.41	4.21	1.6	2.6	10.9
	Gas ± Check %		+150.2		+130.4					+119	+81	+144
7	Gas	..	221.6	17.45	38.7	8.67	11.58	79.75	6.88	3.4	4.5	30.8
	Check	..	154.8	14.66	22.7	7.21	18.87	73.92	3.91	1.6	4.3	16.8
	Gas ± Check %		+43.1		+70.5					+113	+4.7	+83.3
						Stems						
5	Gas	..	52.6	20.49	10.8	11.89	13.74	74.37	5.41	1.3	1.5	8
	Check	..	24.5	21.58	5.3	11.41	15.89	72.71	4.57	0.6	0.8	3.9
	Gas ± Check %		+114.7		+103.8					+117	+88	+105
6	Gas	..	343.5	15.93	54.7	14.33	9.83	75.84	7.72	7.8	5.4	41.5
	Check	..	184.6	17.34	32	14.77	12.82	72.41	5.64	4.7	4.1	26.2
	Gas ± Check %		+86.1		+70.9					+66	+32	+58.4
7	Gas	..	287.7	17.92	51.6	10.75	8.19	81.06	9.90	5.5	4.2	41.9
	Check	..	237.4	16.03	38	12.21	12.73	75.06	5.91	4.6	4.8	28.7
	Gas ± Check %		+21.2		+34.1					+19.6	−12.5	+46
						Leaves						
5	Gas	..	91	17.51	15.9	19.27	27.46	53.27	1.94	3.1	4.4	8.4
	Check	..	42	19.74	8.3	18.08	27.91	54.01	1.94	1.5	2.3	4.5
	Gas ± Check %		+116.7		+91.6					+107	+91	+87
6	Gas	..	394.5	15.70	61.9	17.66	22.57	59.77	2.65	10.9	14	37
	Check	..	207.8	19.05	39.6	15.47	23.96	60.57	2.53	6.1	9.5	24
	Gas ± Check %		+89.8		+56.3					+79	+47	+54
7	Gas	..	313.2	18.63	58.4	13.94	20.65	65.41	3.17	8.1	12	38.3
	Check		271.6	18.75	50.9	13.93	20.52	65.55	3.26	7.1	13.5	30.3
	Gas ± Check %		+15.4		+14.7					+14	−11	+26.4

The gassed plants as compared with the checks:

(*a*) Weighed more in every crop and in every separate.

(*b*) Contained more dry matter in every crop and in every separate.

The gains were especially noticeable in the seed. The yield was always more than doubled and in one case trebled following gas treatment. The other plant structures likewise responded vigorously. There is nothing noteworthy as regards the ash percentages, though the trend was towards lessened ash content in the gassed than the ungassed plants. The same situation holds for the protein content.

In order the better to exhibit the relationship existing between the nitrogenous and the carbonaceous constituents, the following table, similar to that heretofore shown in connection with the bean analyses, is presented, covering in this case, however, not only the complete analyses but also the separates. It will be noted that the general trend, seen most readily in the ratio statement, is all in one general direction, namely, a relative concentration of carbohydrate material in the gassed plants as a whole and in their several separates.

TABLE VI. PEAS: QUALITY OF ORGANIC MATTER, ENTIRE PLANT AND SEPARATES

		Crude protein %	Carbohydrates and ether extract %	Ratio 1:			Crude protein %	Carbohydrates and ether extract %	Ratio 1:
4	Gas....	26.43	73.57	2.78	6	Gas....	22.71	77.29	3.40
	Check..	26.78	73.22	2.73		Check..	23.88	76.12	3.19
5	Gas....	24.75	75.25	3.04	7	Gas....	20.03	79.91	3.99
	Check..	24.77	75.23	3.04		Check..	24.05	75.95	3.16
		Seeed				*Stems* (including petioles)			
5	Gas....	28.18	71.82	2.55	5	Gas....	16.60	84.40	5.41
	Check..	28.27	71.73	2.54		Check..	17.94	82.06	4.57
6	Gas....	29.58	70.42	2.38	6	Gas....	11.46	88.54	7.72
	Check..	29.30	70.70	2.41		Check..	15.05	84.95	5.64
7	Gas....	26.67	73.33	2.75	7	Gas....	9.19	90.81	9.88
	Check..	28.77	71.23	2.48		Check..	14.50	85.50	5.90
		Pods				*Leaves*			
5	Gas....	14.48	85.52	5.91	5	Gas....	34.03	65.97	1.94
	Check..	15.40	84.60	5.49		Check..	34.09	65.91	1.93
6	Gas....	15.00	85.00	5.67	6	Gas....	27.42	72.58	2.65
	Check..	19.23	80.77	4.20		Check..	28.35	71.65	2.53
7	Gas....	12.70	87.30	6.87	7	Gas....	24.00	76.00	3.17
	Check..	20.34	79.66	3.92		Check..	30.80	69.20	3.25

Another point worthy of note in connection with the modification in the proportions and gross amount of nutrients following the gas dosage, is the relation of the amount of sunshine and the duration of the trial to the carbohydrate content of the product. The following

table shows that the ratio of protein to carbohydrates tends to decrease with the treated as compared with the untreated plants as the time element increases. When the trials continued for from 7 to 10 weeks, the ratios were the same for each lot; but when it extended for 15 or more weeks a higher carbohydate content occurred in the treated plants even though the available sunlight was considerably less. That this is not due solely to increased maturity may be safety asserted in view of the fact that the ratio of the check plants was not materially changed when grown the longer time.

TABLE VII. RELATION OF SUNSHINE AND DURATION OF TRIAL TO CARBOHYDRATE CONTENT

Trial	Date of harvest	Days of growth	Percentage of sunshine	Season	Days of treatment	Ratio of protein to carbohydrate, etc.	
						Gas. 1:	Check 1:
4	Sept. 8, '14..	55	52	July to Sept.	50	2.78	2.73
5	Nov. 25, '14..	92	39	Aug. to Nov.	71	3.04	3.04
6	Feb. 8, '15..	131	33	Sept. to Feb.	116	3.40	3.19
7	Mar. 9, '15..	131	42	Oct. to Mar.	103	3.99	3.16

Obviously the carbohydrates in the gas-treated crops must be larger than that in the untreated crop if the ash and protein figures are lowered. In nine of the twelve separates this is the fact and in three it is not. In none of these exceptions is there any material difference between the two lots.

This outcome exactly parallels that observed with the beans. The same phraseology, word for word, could be used in each instance and be accurate. The writers again state their belief that this result is not due to chance, but that cause and effect exist.

IV. INFLUENCE ON UNDERGROUND STRUCTURES

The radish and the potato, two widely dissimilar plants, were selected as types to represent groups of plants which develop edible subterranean plant structures. One is of rapid and the other of slow culture; one is low and the other high in nutritive values; one is a cool and the other a warm temperature plant.

1. RADISHES

Radishes grow quickly and easily, their roots are shallowly disposed and their edible portions are fleshy but watery, the dry matter constituting only but six or seven percent. On these accounts this crop seemed especially adapted to the purpose of the carbon dioxid

trials. These were begun in October, 1912, and were concluded in April, 1913, thus embracing the common radish forcing months, seven successive crops being grown. Gas was supplied for eight hours daily, beginning as soon as germination was completed and green leaves were developed and continuing without interruption until harvest. In most instances the crop grew until the roots were marketable.

(*a*) PHYSICAL ANALYSES

The tops and roots were separately weighed in five of the seven trials. The gassed tops outweighed the check tops in each instance, and so did the roots in all but a single instance (Table VIII, 5), when the plants were crowded in the gas plot as compared with the check. The top gains in weight ranged from 1 to 23 percent, averaging 10 percent; the root gains from 8 to 46 percent, averaging 19 percent.

Among the series which responded favorably, which occurred in four out of five instances, the smallest gain was 4 percent and the greatest 46 percent, averaging 19 percent. Thus it is seen that the roots rather than the tops were specially stimulated to greater growth.

The character of the leaves was not greatly modified. The gassed plants were notably more green, indicating increased chlorophyll development. The leaf lamina were scarcely changed but the leaf stalks were somewhat lengthened.

The data relative to the physical analyses are displayed in the following table:

TABLE VIII. RADISHES: PHYSICAL ANALYSES

(1) November 27-December 31, 1912. 35 days, 27 percent sunshine. (2) November 26, 1912-January 7, 1913. 42 days, 31 percent sunshine.

Treatment	Plants: number	Green weight grams	Average weight grams	Plants: number	Green weight grams	Average weight grams
Gas	163	98.8	0.61	334	328	0.98
Check	206	118.8	0.58	328	300	0.91
Gas ± Check %			+5.2			+7.7

(3) January 1-February 17, 1913. 48 days, 33 percent sunshine.

Treatment	Plants: number	Weight of plants		Weight of tops		Weight of roots	
		Total grams	Average grams	Total grams	Average grams	Total grams	Average grams
Gas	72	552	7.67	360	5	192	2.67
Check	101	745	7.38	500	4.95	245	2.43
Gas ± Check %			+4.7		+1.		+9.5

(4) January 10-February 19, 1913. 40 days, 34 percent sunshine.							
Gas	65	563	8.66	319	4.91	244	3.75
Check	85	516	6.07	371	4.37	145	1.71
Gas ± Check %			+42.7		+12.4		+119.3
(5) February 22-March 18, 1913. 24 days, 39 percent sunshine.							
Gas	233	2024	8.68	1168	5.01	856	3.67
Check	215	1803	8.38	948	4.41	855	3.98
Gas ± Check %			+3.6		+13.6		—7.8
(6) February 21-March 19, 1913. 26 days, 39 percent sunshine.							
Gas	63	640	10.14	365	5.79	275	4.37
Check	65	538	8.29	345	5.31	193	2.97
Gas ± Check %			+22		+9		+47.2
(7) March 21-April 1, 1913. 12 days, 20 percent sunshine.							
Gas	242	1979	8.18	1430	5.91	549	2.27
Check	226	1771	7.84	1279	5.66	492	2.18
Gas ± Check %			+44		+4.4		+4.1

Although the results secured in the second trial were of little account, the plants being spindling, illshapen, not forming roots, nevertheless they are included. The planting was too thick, sunlight insufficient and perhaps the temperature too high. The results were positive, although the percentage of gain was quite variable. The gassed plants, tops and roots alike, weighed more than the untreated lots.

(*b*) CHEMICAL ANALYSES

Chemical analyses were made of seven consecutive crops of treated and untreated radishes. The several tables which follow give the analytical data for the entire plant and in five instances of the separates. They show the percentage composition and the yield of the several constituents. It being impracticable to grow the same numbers of plants in the treated and untreated areas and difficult to select equal numbers for harvest and analyses without introducing possible error, the dry matter and constituent yields have been calculated in each instance to the uniform basis of one plant.

WEIGHTS OF INGREDIENTS IN GRAMS

A statement of the ingredients of the treated and untreated radish plants, expressed on the basis of dry weights appears herewith, for the entire plants and the separates.

LE IX. RADISHES: ENTIRE PLANTS AND SEPARATES; CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS

	Green weight	Dry matter	Dry matter	100 parts dry matter contain			Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
				Ash	Protein	Carbohydrates and ether extract				
	grams	%	grams	%	%	%	1:	grams	grams	grams
Gas	61	6.68	4.1	22.65	33.55	43.80	1.31	0.9	1.4	1.8
Check	58	6.35	3.7	21.64	35.06	43.30	1.24	0.8	1.3	1.6
Gas ± Check %	+5		+11					+13	+8	+13
Gas	98	5.92	5.8	25.21	34.15	40.64	1.19	1.5	2	2.4
Check	91	6.03	5.5	27.05	34.37	38.58	1.12	1.5	1.9	2.1
Gas ± Check %	+7		+5					0	+6	+15
Gas	767	7.53	56.6	22.45	28.51	49.04	1.72	12.7	16.1	27.7
Check	738	7.20	52.4	22.56	29.02	48.42	1.67	11.8	15.2	25.4
Gas ± Check %	+3.9		+8					+7.6	+5.9	+9.1
Gas	866	6.71	56.8	19.96	26.84	53.20	1.98	11.3	15.3	32.2
Check	607	7.16	42.9	20.57	28.97	50.46	1.74	8.8	12.4	21.6
Gas ± Check %	+42.7		+32.4					+28.4	+23.4	+49.1
Gas	868	6.08	37	22.03	25.68	52.29	2.04	8.2	9.5	19.4
Check	838	6.36	35.9	23.18	28.54	48.28	1.69	8.3	10.3	17.3
Gas ± Check %	+3.6		+3.1					—1	—7.8	+12.1
Gas	1014	5.83	58.8	21.89	27.64	50.46	1.83	12.9	16.3	29.7
Check	829	6.28	51.4	23.65	29.01	47.34	1.63	12.2	14.9	24.3
Gas ± Check %	+22.3		+14.4					+6.3	+9.4	+22.2
Gas	818	6.18	50.5	23.81	26.37	49.82	1.89	12	13.3	25
Check	784	6.29	49.3	23.61	28.38	48.02	1.69	11.6	14	23.7
Gas ± Check %	+4.2		+2.4					+3.4	—5	+6.3
Tops										
Gas	500	8.17	40.9	22.97	30.45	46.58	1.53	9.4	12.4	19
Check	495	7.66	37.9	22.96	31.09	45.95	1.48	8.7	11.8	17.4
Gas ± Check %	+1		+7.9					+8	+5.1	+9.2
Gas	491	7.43	36.5	22.01	29.91	48.08	1.61	8	10.9	17.5
Check	437	7.55	32.9	21.09	31.07	47.84	1.54	7	10.2	15.7
Gas ± Check %	+12.4		+10.9					+14	+6.9	+11.5
Gas	501	6.84	22	22.64	29.88	47.48	1.59	5	6.6	10.5
Check	441	7.18	21.7	24.88	31.91	43.21	1.35	5.4	6.9	9.4
Gas ± Check %	+13.6		+1.5					—8	—4	+12
Gas	579	6.20	35.9	23.27	30.48	46.25	1.52	8.4	11	16.6
Check	531	6.72	35.7	24.65	30.92	44.43	1.44	8.8	11	15.9
Gas ± Check %	+9		+0.6					—5	0	+4.4
Gas	591	6.13	36.2	24.39	26.46	49.15	1.86	8.8	9.6	17.8
Check	566	6.33	35.8	24.09	29.40	46.51	1.58	8.6	10.5	16.6
Gas ± Check %	+4.4		+1.1					+2	—8.6	+7.2
Roots										
Gas	267	5.88	15.7	21.10	23.45	55.45	2.36	3.3	3.7	8.7
Check	243	6.00	14.5	21.54	23.64	54.82	2.32	3.1	3.4	8
Gas ± Check %	+9.9		+8.3					+7	+9	+9
Gas	375	5.41	20.3	16.24	21.33	62.43	2.93	3.3	4.3	12.7
Check	171	5.86	10	28.86	22.04	59.10	2.68	2.9	2.2	5.9
Gas ± Check %	+119.5		+103					+74	+95	+115

5	Gas	367	4.98	15	21.14	19.49	59.37	3.05	3.2	2.9
	Check	398	5.10	14.2	20.58	23.41	56.01	2.30	1.9	3.3
	Gas ± Check %	—7.8		+5.6					+10	—12
6	Gas	437	5.25	22.9	19.75	23.19	57.06	2.46	4.5	5.3
	Check	297	5.27	15.7	21.35	24.69	53.96	2.19	3.4	3.9
	Gas ± Check %	+47.2		+45.9					+32	+36
7	Gas	227	6.32	14.3	22.35	26.15	51.50	1.97	3.2	3.8
	Check	217	6.20	13.5	22.31	25.67	52.02	2.03	3	3.5
	Gas ± Check %	+4.6		+5.9					+7	+9

It should be noted:

(1) That every gassed radish crop and every lot of gassed tops and of roots weighed more, contained more dry matter and carbohydrates and exhibited higher carbohydrate and lower protein percentages than did their respective mates, with these minor exceptions: green weight, one lot of roots: carbohydrates and protein, one lot of roots.

(2) That in five of seven instances the entire gassed crops and in four of five instances the gassed roots were somewhat more succulent than those grown without special treatment; however, the differences often were but slight.

(3) That on the whole the roots responded more readily than the tops to gas dosage. The outcome is perfectly definite, all in one direction, yet the results were less pronounced than in the case of the legumes. It is not to be expected that all sorts and conditions of plants will respond equally well to this stimulant. It seems significant, however, that each does respond to a greater or less degree.

According to physical analyses the gas treatment gave positive results in every instance, although the degree of benefit was quite variable, slightly earlier edible maturity and increase in weight of both tops and roots being secured. According to chemical analyses, more total dry matter and nitrogen-free-extract were produced in the gassed than in the untreated crops as a whole, while the roots grown on the carbon dioxid areas contained larger amounts of all nutrients, dry matter, ash, protein and carbohydrates, than the checks.

2. Potatoes

Uniformity and similarity of tubers were insured so far as might be by careful selection. They were cut lengthwise so that each half would contain equal proportions of "rose and heel" ends. These were then trimmed on the inner cut surface so as to weigh about 70 grams each and sprouted and allowed about two weeks in which to develop

roots and foliage. The plants were then again compared, standardized as to size, stature and apparent vigor, and, in case inequalities existed, the paired plants were discarded. Then the treatment was inaugurated.

(*a*) PHYSICAL ANALYSES

The influence of carbon dioxid on the potato is shown in the records of 10 experiments as follows:

TABLE X. POTATOES: PHYSICAL ANALYSES

	Leaflets Number	Leaflets Weight grams	Tubers Number	Tubers Weight grams	Leaflets Number	Leaflets Weight grams	Tubers Number	Tubers Weight grams
) July 12-October 27, 1913. 107 days, 52 percent sunshine.					(2) January 5-March 4, 1914. 58 days, 40 percent sunshine.			
as	605	.....	22	1550	.....	.....	6	249
ieck	265	.....	30	508	.....	.....	7	151
as ± Check....	+340	.....	— 8	+1042	.....	.....	— 1	+98
as ± Check %..	+128.3	.....	—26.6	+ 205.1	.....	.....	—14.3	+64.9
) April 1-May 21, 1914. 51 days, 43 percent sunshine.					(4) June 4-August 12, 1914. 69 days, 52 percent sunshine.			
as	912*	.....	55*	1477*	5609	.....	28	306
heck	2511	.....	19	1361	5616	.....	13	72
as ± Check.....	—1599	.....	+ 36	+116	—7	.....	+ 15	+234
as ± Check %..	— 63.7	.....	+189.4	+ 8.5	—0.1	.....	+115.4	+325
5) July 25-September 16, 1914. 53 days, 55 percent sunshine.					(6) July 30-October 28, 1914. 90 days, 50 percent sunshine.			
as	2212	.....	35	103	1587†	.....	21†	856†
heck	3452	.....	61	81	2145	.....	24	778
as ± Check....	—1240	.....	—26	+22	—558	.....	— 3	+78
as ± Check %.	— 35.9	.....	—42.6	+26.5	— 26	.....	—12.5	+10.1
7) September 17-December 11, 1914. 84 days, 37 percent sunshine.					(8) March 12-May 22, 1915. 71 days, 59 percent sunshine.			
as	908	285	35	1131	733	192	14	1038
heck	506	158	22	567	507	113	15	671
as ± Check....	+402	+127	+13	+564	+227	+79	—1	+367
as ± Check %..	+ 79.4	+ 80.4	+59	+ 99.3	+ 44.6	+70	—6.7	+ 54.6
9) March 15-June 4, 1915. 80 days, 52 percent sunshine.					(10) March 12-June 5, 1915. 84 days, 54 percent sunshine.			
as	2633	696	72	2792	3018	785	50	2172
heck	2356	605	28	2617	1627	270	12	1561
as ± Check....	+277	+91	+ 44	+175	+1391	+ 515	+ 38	+611
as ± Check %..	+ 11.7	+15.1	+157.1	+ 6.7	+ 85.5	+191.3	+316.7	+ 39.2

*Red spider infestations and spraying injury.
†Gassed plants died long before checks which remained green.
NOTES.—Two plants used in each gas chamber and check plot in each of the trials except Numbers 4 to 6, inclusive, when four were used.
The premature withering and dropping of some of the foliage in trials 1 to 6, inclusive, initiated weight data and none were taken.

The results as to number of tubers appear inconsistent. The pluses and minuses are equal. However, the gains following gas usage are large, 59, 115, 157, 189 and 317 percents of tubers and the losses are small, 7, 13, 16, 27 and 43 percent. If one considers the outcome in its totality the gas treated plants surpass the checks, the summations being 338 tubers on the one hand and 231 on the other respectively, an increase of 42 percent. However, weight is a fairer basis for comparison, and in this regard the treated plants were superior in every instance, the percentage of gain ranging from 7 to 325, averaging, if one may be permitted to average such profound variables, 83 percent, a very important gain. The treated plants did not begin to form tubers in advance of the untreated lots, but once they got to work they made them faster and grew them larger.

Leaf production does not seem to be correlated with increased tuber weight. For example, there were no more leaves on the crop which made a 325 percent tuber gain than on its utterly outclassed check (Table XI, 4), whereas in one trial, in which only a slight gain—7 percent—was secured as a result of gas dosage, a sixth more leaves grew on the gassed plants.

It appears, therefore, that gassed potato plants as compared with check plants, exhibit greater assimilative powers, carrying on this function at a much faster rate without necessarily increasing the assimilative area. Functional activity of the protoplasm and potential availability of gaseous food are probably responsible for this outcome.

(*b*) CHEMICAL ANALYSES

Four sets of chemical analyses were made, the entire plants, including leaves, stalks and tubers, being analyzed. The usual data are presented in the subjoined tables, expressed in terms of percentages and weight.

The composition of the entire plant on the basis of gram ingredients is shown in the table given below. The treated plants show a large increase in grams of dry matter, protein and nitrogen-free-extract.

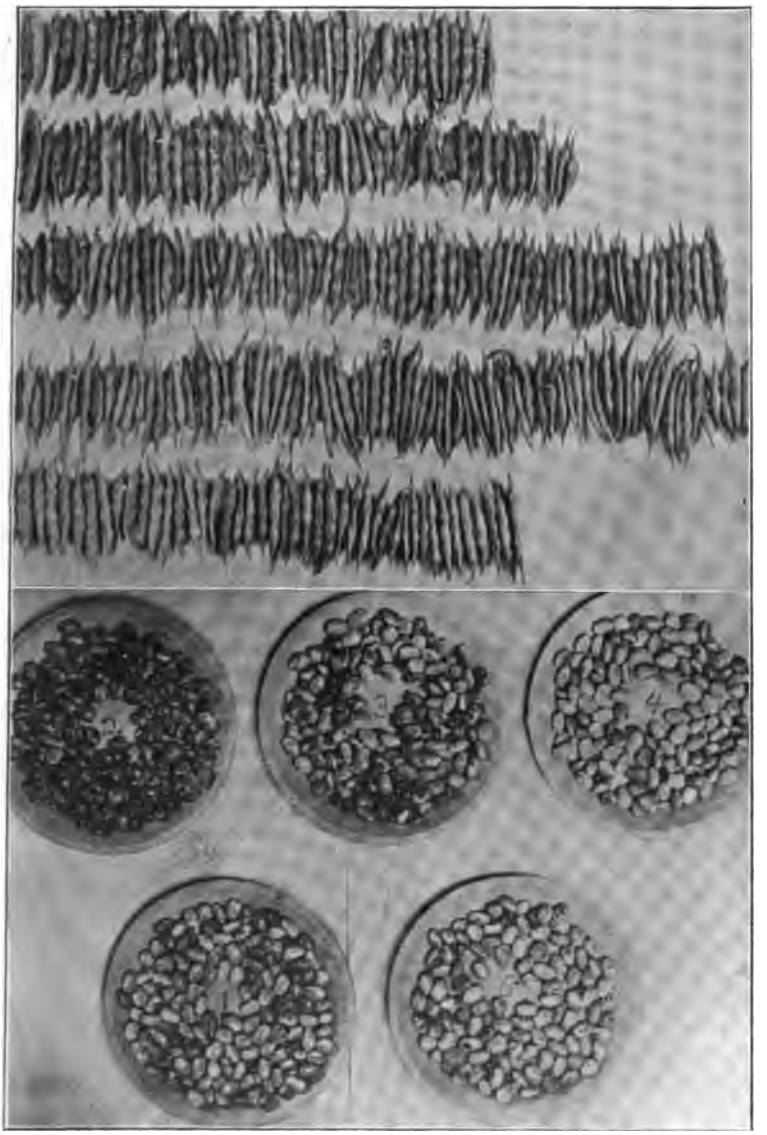

PLATE I.—Influence of different amounts of carbon dioxid on yield of beans. Effect on pod production. Rows 1 to 5 from below upwards received 116, 87, 58, 29, 14½ liters daily.

PLATE II.—Influence of different amounts of carbon dioxid on yield of beans. Effect on bean production. Plates 1 to 5 receiving 116, 87, 58, 29, 14½ liters daily.

PLATE III.—Effect of overdosage with carbon dioxid in closed receptacles. Three stages of injury from left to right.
PLATE IV.—Peas. Gassed product at the left and check product at the right.

PLATE V.—Strawberries. Gassed product lower row. Check product upper row.

PLATE VI.—Cyclamen. Corms; upper row from gassed plants; lower row from check plants.

PLATE VII.—Potatoes. Gassed, left half; check, right half. Salable tubers. Gassed, 9; check, 5.

PLATE VIII.—Beans growing in the experimental box, check plants, at the left; beans growing in the experimental box, gassed plants, at the right. Gas apparatus at extreme right.

TABLE XI. POTATOES: CHEMICAL ANALYSES AND WEIGHTS; ENTIRE PLANT AND SEPARATES

Treatment	Green weight	Dry matter	Dry matter	100 parts of dry matter contain: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
	grams	%	grams	%	%	%	1:	grams	grams	grams
Gas	1649	17.70	291.8	8.22	13.06	77.72	5.95	26.9	38.1	226.8
Check	836	18.38	153.7	9.19	13.26	77.55	5.85	14.1	20.4	119.2
Gas ± Check %	+97.3		+90					+90.8	+86.8	+90.3
Gas	1490	17.66	263.2	9.59	15.25	75.16	4.93	25.2	40.1	197.8
Check	957	17.47	167.2	8.83	16.21	74.96	4.62	14.8	27.1	125.3
Gas ± Check %	+55.7		+57.5					+70.3	+48.1	+57.6
Gas	4839	16.20	783.9	10.31	16.51	73.18	4.43	80.9	129.4	573.6
Check	4377	15.24	710.7	12.10	14.90	73.00	4.90	80	105.9	518.8
Gas ± Check %	+10.3		+10.3					—5.9	+22.2	+10.6
Gas	4080	15.51	632.9	12.27	15.45	72.28	4.68	77.7	97.8	457.4
Check	2601	18.23	474.2	11.57	14.75	73.68	4.99	54.9	70	349.4
Gas ± Check %	+53		+33.5					+41.5	+39.7	+30.9
Tubers										
Gas	1131	20.70	234.1	6.05	12.36	81.59	6.6	14.2	28.9	191
Check	566.5	22.19	125.7	5.70	12.40	81.90	6.6	7.2	15.6	93
Gas ± Check %	+99.6		+86.2					+97	+83.5	+105.5
Gas	1037.5	19.58	203.2	5.79	12.94	81.27	6.28	11.8	26.3	165.
Check	671	19.61	131.6	5.84	13.67	80.49	5.89	7.7	18 .	105.9
Gas ± Check %	+54.5		+54.3					+53	+46.1	+55.8
Gas	2792	18.16	507	5.75	13.52	80.73	5.97	29.2	68.6	409.3
Check	2617	19.23	503.3	5.18	12.23	82.59	6.75	26.1	61.6	415.6
Gas ± Check %	+6.7		+0.7					+11.9	+11.5	—1.5
Gas	2172	16.77	364.3	6.34	12.95	80.71	6.23	23	47.2	294
Check	1561	19.99	312	5.95	11.57	82.48	7.13	18.6	36.1	257.4
Gas ± Check %	+39.2		+16.8					+24.2	+30.8	+14.2
Stalks										
Gas	233	9.20	21.4	17.62	10.60	71.78	6.77	3.8	2.3	15.4
Check	111.5	8.34	9.3	17.99	12.24	69.77	5.7	1.7	1.1	6.5
Gas ± Check %	+109.5		+130					+124	+109	+137
Gas	174	8.51	14.8	24.81	14.20	60.99	4.3	3.7	2.1	9
Check	132.5	7.01	9.3	17.00	16.10	66.90	4.15	1.6	1.5	6.2
Gas ± Check %	+31.7		+59.1					+131	+40	+45
Gas	972	11.83	115	15.86	15.85	68.29	4.31	18.2	18.2	78.5
Check	850	8.99	76.4	19.60	13.12	67.28	5.13	15	10	51.4
Gas ± Check %	+14.3		+50.5					+21.3	+82	+52.7
Gas	781	12.50	97.6	14.49	12.93	72.58	5.61	14.2	12.6	70.9
Check	626	13.12	82.1	24.12	16.10	59.78	3.71	19.8	13.2	49.1
Gas ± Check %	+24.8		+18.9					—29.3	—4.5	+44.4
Petioles										
Gas	379.5	12.08	45.9	16.20	18.38	65.42	3.56	7.4	8.4	30
Check	305	7.68	23.4	27.54	16.42	56.04	3.41	6.5	3.9	13.1
Gas ± Check %	+24.9		+91.5					+13.8	+115	+129
Gas	341.5	9.63	32.9	27.45	13.57	58.98	4.35	9	4.5	19.4
Check	144.5	9.88	14.3	26.82	17.07	56.11	3.29	3.8	2.4	8
Gas ± Check %	+136.4		+130.1					+137	+88	+143

					Leaflets						
9	Gas	695.5	16.68	116.1	22.44	29.48	48.08	1.63	26	34.2	55.
	Check	604.5	17.80	107.6	35.76	28.29	35.95	1.27	38.5	30.4	33.
	Gas ± Check %	+15.1		+7.9					−32.5	+12.5	+44.
10	Gas	785	17.60	138.2	22.73	24.28	52.99	2.18	31.4	33.6	73.
	Check	269.5	24.41	65.7	19.21	27.65	53.14	1.92	12.6	18.2	35.
	Gas ± Check %	+191.3		+110.4					+149.2	+84.6	+109.
					Leaves (including petioles)						
7	Gas	285	12.73	36.2	24.70	19.05	56.25	2.95	9	6.9	20.
	Check	158	11.82	18.7	28.29	19.49	52.22	2.68	5.3	3.6	9.
	Gas ± Check %	+80.4		+93.6					+70	+92	+107.
8	Gas	278.5	16.23	45.2	21.55	25.99	52.46	2.02	9.7	11.8	22.
	Check	153.5	17.15	26.3	20.93	28.91	50.16	1.74	5.5	7.6	13.
	Gas ± Check %	+81.4		+71.9					+76	+55	+73.

The data presented in tables show that:

(1) The gassed crops weighed more than the checks in the instances (7-10) where full weights were taken and probably in at least three of the six earlier trials.

(2) The gassed crops submitted to chemical analysis contained more total dry matter and more of each constituent than did the checks.

(3) Each of the several separates of the gassed crops weighed more and contained more dry matter than its corresponding check.

(4) In 38 of the 42 comparisons of constituents the gassed material outclassed the untreated. Two of the exceptions were located in the crude ash and are likely to be due to extraneous material (soil mechanically held in leaflets), and one of the other two is a minor difference. The only significant exception occurs in the tubers of lot 9.

(5) The ratios are not as clear cut and significant as in the previously reported trials on legumes and radishes. There appears to be no marked effect tending to increase the carbohydrate percentages following gas dosage when applied to the potato plant.

In short, carbon dioxid treatment seems favorably to affect the gross weights of the entire plant and of the tubers but not materially to alter their composition.

V. INFLUENCE ON FOLIAGE CROPS

1. ENDIVE

Endive was used partly because of its tolerance of summer temperature in greenhouses, but chiefly because of the fact that the crop may be cut successively. This latter possibility offered an opportunity to study its recuperative powers under experimental conditions. Aside from preliminary trials, only one recorded experiment was performed.

the results of which are presented herewith, beginning July 20 and continuing until November 3. Four foliage cuttings were made during this period and at the termination of the trial the roots were compared.

(*a*) PHYSICAL ANALYSES

The physical data follow:

TABLE XII. ENDIVE: PHYSICAL ANALYSIS

Four cuttings Sept. 19, Oct. 10, Nov. 1, Nov. 3, 1912. 14-14 plants, 45 to 47 percent sunshine.

	Number of leaves				Weight of leaves				Weights at harvest		
	I	II	III	IV total	I	II	III	IV	Total	Stalks	Roots
					gr.	gr.	gr.	gr.	gr.	gr.	gr.
as	299	628	710	1637	869	1054	687	117	2727	54	75
heck	274	626	645	1543	596	933	749	125	2403	44	66
as ± Check..	+25	+2	+65	+92	+273	+121	—61	—8	+324	+10	+9
as ± Check %	+9.1	+0.3	+10.1	+5.9	+45.8	+13	—8.2	—6.4	+13.5	+22.7	+13.6

Endive benefits by gas treatment. The treated plants produced 6 percent more leaves than the checks, which furthermore were larger, weighing 13.5 percent more than the check leaves. Then again, the earlier leaves were much larger on the treated plants than on their mates, as is clearly shown in the weight data. And, finally, the roots of the treated plants weighed one-seventh more than did those of the check plants.

(*b*) CHEMICAL ANALYSES

The following tables show the analyses of the several cuttings expressed in terms of percentages and of weights of constituents. Unfortunately through some oversight no analyses of the cuttings of the whole plants on November third were made and hence it is impossible to make an aggregate of the entire crop which shall be accurate. It is assumed for the purposes of this calculation, however, that the leaf and stalk cuttings of November third were of the same composition as the leaf cuttings made only two days previous. It is not thought that serious error is thus introduced.

TABLE XIII. ENDIVE: CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS; ENTIRE CROP AND SEPARATES

		Green weight	Dry matter	Dry matter	100 parts dry matter: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
		grams	%	grams	%	%	%	1:	grams	grams	grams
	Gas	2856	6.99	197.9	23.27	25.99	50.74	1.95	46.1	51.4	100.4
	Check	2513	6.63	166.8	23.00	24.75	52.25	2.11	38.3	41.3	87.2
	Gas ± Check %	+13.7		+18.6					+20.4	+24.5	+15.
					Leaves						
I	Gas	869	6.43	55.9	22.40	31.57	46.03	1.46	12.5	17.7	25.7
	Check	596	6.35	37.8	22.52	19.06	58.42	3.06	8.5	7.2	22.1
	Gas ± Check %	+45.8		+47.9					+47	+146	−16
II	Gas	1054	6.09	64.3	22.02	24.84	53.14	2.14	14.2	16	34.2
	Check	933	5.96	55.6	23.04	28.90	48.06	1.66	12.8	16.1	26.7
	Gas ± Check %	+13		+15.6					+10.2	−0.6	+28.1
III	Gas	858	7.84	67.3	25.69	23.85	50.46	2.12	17.3	16.1	34
IV	Check	918	6.96	63.9	23.51	25.61	50.88	1.99	15	16.4	32.5
	Gas ± Check %	−6.5		+5.3					+15.3	−1.8	+4.6
					Roots						
	Gas	75	13.92	10.4	20.15	16.69	63.16	3.79	2.1	1.7	6.6
	Check	66	14.45	9.5	20.68	17.76	61.56	3.47	2	1.7	5.9
	Gas ± Check %	+13.3		+9.5					+5	0	+11.9

The gas-treated crop contained more dry matter than the checks; and so did each of the separate cuttings. Each separate of the gassed plants contained more carbohydrates than the corresponding separate from the check plants. However, this was due to the increased size of the crop rather than to material changes in chemical composition, for nothing very definite appears as to that matter, except that the gassed plants and their separates were somewhat richer in dry matter than their competitors.

2. Lettuce

Lettuce is the most important economic salad plant grown in America. Not only is it raised out of doors, but it is grown on a large scale as a glass house product, being much prized for salads out of season. It represents in a very typical manner those crops that are grown for foliage production. Its thin and expansive leaves present unusually large surface areas for assimilation. It is relatively low in nutritive constituents, containing about 94 percent water, 1.5 percent each of protein and ash and 2.2 percent of carbohydrates. It appeared peculiarly well adapted to the purposes of these trials.

The crops were grown at different times from February, 1911 to March, 1914. Varying numbers of plants were used in the several trials, ranging from 3 to 18, the same numbers being employed on each side in any given trial.

(*a*) PHYSICAL ANALYSES

The results are stated in terms of numbers of leaves per plant and weights of the entire plant above ground.

TABLE XIV. LETTUCE: PHYSICAL ANALYSES

Dates, days, sunshine and plants	Treatment	Leaves number	Weight grams
(1) 2/26-4/3/11	Gas	39.3	236.66
36 days, 56% sunshine	Check	37.7	151.66
3 and 3 plants	Gas ± Check %	+4.2	+56.1
(2) 2/22-4/14/11	Gas	31.7	120.66
51 days, 55% sunshine	Check	28	85.16
3 and 3 plants	Gas ± Check %	+13.2	+41.7
(3) 11/28-12/18/11	Gas	6.1	18.22
20 days, 22% sunshine	Check	5.7	17.66
17 and 17 plants	Gas ± Check %	+7.1	+3.2
(4) 11/28/11-1/8/12	Gas	22.8	49.29
41 days, 16% sunshine	Check	20.7	42.22
8 and 8 plants	Gas ± Check %	+10.1	+16.7
(5) 11/28/11-1/22/12	Gas	31.7	83.35
55 days, 15% sunshine	Check	29.5	78
10 and 10 plants	Gas ± Check %	+7.5	+6.9
(6) 1/10-1/31/12	Gas	16	9.45
21 days, 15% sunshine	Check	17.3	10.53
3 and 3 plants	Gas ± Check %	—7.5	—10.3
(7) 1/3-2/15/12	Gas	19.3	38.75
44 days, 51% sunshine	Check	18	25.35
10 and 10 plants	Gas ± Check %	+7.2	+52.9
(8) 2/23-4/2/12	Gas	...	179.25
40 days, 48% sunshine	Check	...	174.13
8 and 8 plants	Gas ± Check %	...	+2.9
(9) 2/23-3/20/12	Gas	18	20.33
25 days, 50% sunshine	Check	16	25.5
3 and 3 plants	Gas ± Check %	+12.5	—20.3
(10) 3/4-3/20/12	Gas	19.6	36.13
17 days, 54% sunshine	Check	17.7	24.36
11 and 11 plants	Gas ± Check %	+10.8	+48.3
(11) 2/29-4/4/12	Gas	27.2	91.65
36 days, 54% sunshine	Check	23.6	54.53
17 and 17 plants	Gas ± Check %	+15.3	+68.1
(12) 4/3-4/29/12	Gas	30.6	112.37
27 days, 53% sunshine	Check	27.8	110.37
8 and 8 plants	Gas ± Check %	+10.1	+1.8
(13) 4/7-5/1/12	Gas	26.8	76
24 days, 56% sunshine	Check	22.3	48.33
9 and 9 plants	Gas ± Check %	+20.2	+57.3

TABLE XIV. LETTUCE: PHYSICAL ANALYSES—*continued*

Dates, days, sunshine and plants	Treatment	Leaves number	Weight grams
(14) 4/7-5/9/12	Gas	28.3	103.7
32 days, 35% sunshine	Check	26.2	78.59
17 and 17 plants	Gas ± Check %	+8	+32
(15) 5/4-5/29/12	Gas	26.5	98.3
26 days, 52% sunshine	Check	24.3	73
6 and 6 plants	Gas ± Check %	+9.1	+34.7
(16) 5/10-6/8/12	Gas	24.5	97.12
28 days, 48% sunshine	Check	22.8	86.87
8 and 8 plants	Gas ± Check %	+7.5	+11.8
(17) 6/15-7/8/12	Gas	17.4	54.5
23 days, 70% sunshine	Check	14.4	43.12
8 and 8 plants	Gas ± Check %	+20.8	+26.4
(18) 10/15-12/11/13	Gas	30	91.83
58 days, 28% sunshine	Check	26.7	95.11
18 and 18 plants	Gas ± Check %	+12.4	—3.4
(19) 10/24-12/13/13	Gas	29	65.2
61 days, 23% sunshine	Check	29	88.03
6 and 6 plants	Gas ± Check %	0	—25.9
(20) 12/12/13-2/7/14	Gas	35.2	119.15
67 days, 35% sunshine	Check	27.5	87.47
11 and 11 plants	Gas ± Check %	+28	+36.2
(21) 12/15/13-2/4/14	Gas	34.6	143.1
68 days, 23% sunshine	Check	30.6	118.6
3 and 3 plants	Gas ± Check %	+13.1	+20.7
(22) 1/13-2/17/14	Gas	37.5	127.87
35 days, 40% sunshine	Check	27.5	96.3
4 and 4 plants	Gas ± Check %	+36.4	+32.8
(23) 2/19-3/26/14	Gas	35.4	143
33 days, 46% sunshine	Check	33.3	98.5
12 and 12 plants	Gas ± Check %	+6.3	+45.2
(24) 2/21-3/31/14	Gas	28.8	90.25
38 days, 43% sunshine	Check	29	85.75
4 and 4 plants	Gas ± Check %	—4.7	+5.3
(25) 3/8-3/31/14	Gas	24	40.9
24 days, 39% sunshine	Check	24	44.44
9 and 9 plants	Gas ± Check %	0	—8

In 20 of the 25 trials, the results expressed in terms of weight favored the gas treatment and in three of the five instances in which the exception tended to prove the rule, the differences in favor of the checks were not large. There may have been lack of vigor on the part of the gassed plants in these cases, not apparent at the outset of the trials. The results as a whole were highly variable but on the average the gain was about 21 percent. The stimulating effect of an extra carbon dioxid dosage was also shown in the increased number of the leaves. With four exceptions, there were more leaves on the treated plants than on the checks, the average gains approximating 10 purposes.

The crimpy and curly nature of the lettuce leaves made it impossible to secure accurate and reliable planimeter determinations of leaf areas in relation to leaf weight. No perceptible differences in the "heading up" capabilities were recognizable.

Certain unfavorable results were noticeable. For example, the treated plants were usually, although not always, of a darker green color than their mates, owing to the greater development of chlorophyll, a condition which rendered the foliage parts less palatable. Their leaves were also somewhat tougher and hence less desirable for table percent.

(*b*) CHEMICAL ANALYSES

The usual chemical analyses were made of 11 of the 25 crops with results as shown on the subjoined table:

TABLE XV. LETTUCE: CHEMICAL ANALYSES

		Green weight	Dry matter	Dry matter	100 parts of dry matter contain			Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
					Crude ash	Crude protein	Carbohydrates and ether extract				
		grams	%	grams	%	%	%	1:	grams	grams	grams
3	Gas	18.22	4.38	0.8	24.43	36.30	39.27	1.08	0.2	0.3	0.3
	Check	17.66	4.93	0.9	21.30	33.47	45.23	1.35	0.2	0.3	0.4
	Gas ± Check %	+3.2		—11					0	0	—25
16	Gas	97.12	5.32	5.2	20.64	35.33	44.03	1.25	1.1	1.8	2.3
	Check	86.87	5.05	4.4	20.53	36.71	42.76	1.16	0.9	1.6	1.9
	Gas ± Check %	+11.8		+18					+22	+13	+21
17	Gas	54.5	6.56	3.6	27.40	36.24	36.36	1	1	1.3	1.3
	Check	43.12	4.81	2.1	27.35	34.87	37.78	1.08	0.6	0.7	0.8
	Gas ± Check %	+26.4		+71					+40	+86	+63
18	Gas	91.83	4.70	4.3	25.13	30.01	44.86	1.5	1.1	1.3	1.9
	Check	95.11	4.26	4.1	29.63	29.68	40.69	1.37	1.2	1.2	1.7
	Gas ± Check %	—3.5		+5					—8	+8	+12
19	Gas	65.2	5.71	3.7	26.30	26.63	47.07	1.77	0.9	0.9	1.9
	Check	88.02	4.60	4.1	27.12	27.98	44.90	1.6	1.1	1.1	1.9
	Gas ± Check %	—26.1		—10					—18	—18	0
20	Gas	119.15	5.26	6.3	18.42	27.30	54.28	1.99	1.1	1.7	3.5
	Check	87.47	5.85	5.1	20.09	30.30	49.61	1.64	1	1.5	2.6
	Gas ± Check %	+36.2		+24					+10	+13	+35
21	Gas	143.1	6.57	9.4	25.50	27.10	47.40	1.75	2.3	2.4	4.7
	Check	118.6	6.32	7.5	26.48	27.41	46.11	1.68	1.9	2	3.6
	Gas ± Check %	+20.7		+25					+21	+20	+19
22	Gas	127.87	5.26	6.8	18.42	27.30	54.28	1.99	1.2	1.9	3.7
	Check	96.3	5.85	5.6	20.09	30.30	49.61	1.64	1.1	1.8	2.7
	Gas ± Check %	+32.8		+21					+9	+5	+37
23	Gas	143	...	..	24.07	31.06	44.87	1.44	..	..	..
	Check	98.5	...	..	23.93	32.56	43.51	1.34	..	..	..
	Gas ± Check %	+45.2									
24	Gas	90.25	5.91	5.3	20.60	30.34	49.06	1.62	1.1	1.6	2.6
	Check	85.75	6.02	5.2	21.21	32.68	46.11	1.41	1	1.7	2.4
	Gas ± Check %	+52.5		+2					+10	—6	+8
25	Gas	40.9	5.01	2.1	23.52	30.32	46.16	1.52	0.5	0.6	1
	Check	44.44	5.15	2.3	22.99	29.18	47.83	1.64	0.5	0.7	1.1
	Gas ± Check %	—8		—9					0	—14	—9

It will be noted concerning the lettuce:

(1) That the crop was greater in 21 of 25 instances when carbon dioxid dosage was applied;

(2) That in seven of the eleven crops analyzed the dry matter content of the gassed crop was greater than that of the checks;

(3) That in eight of the eleven cases the carbohydrate percentage was greater in the gassed than in the check crops and that in seven of

the eleven instances the protein content was lower in the treated than the untreated plants;

(4) That the gross yields of carbohydrates were greater following the gas dosage.

It should be remembered that the lettuce is not bought as is bread, as a staff of life, but, rather, for its succulence, its flavor, for the zest and finish it gives to a meal. Its food value, other than its mineral content which of course is distinctly beneficial, is negligible. That being the case, the ill effect of the gas dosage upon the texture and color of the leaf as noted above is to be taken into account.

3. SWISS CHARD

The Swiss chard trial was made in the summer and fall, beginning July 16 and continuing until November 16. The greenhouse temperature was high at the outset and always too warm. Shade was provided in order partially to alleviate this situation and to avoid leaf scorching. This may have lowered somewhat the assimilative capacities of the plants. Notwithstanding this untoward condition, the results are interesting as tending to show the benefit which Swiss chard may derive from an extra carbon dioxid dosage when growing in diffused light.

The crop was grown in bench soil and horizontally enclosed in boxes with glass sides and open tops.

(*a*) PHYSICAL ANALYSES

Four successive cuttings of the foliage were made as the leaves attained edible size during the four-month period.

TABLE XVI. SWISS CHARD: PHYSICAL ANALYSES

Leaves cut Aug. 22, Sept. 11, Oct. 10, Nov. 16, 1912. 7-7 plants. 55 percent sunlight, 51 percent sunlight, 40 percent sunlight, 42 percent sunlight.

		Green weight grams	Leaves number	Leaves weight grams	Petioles number	Petioles weight grams	Leaves surface area sqr.
I	Gas	350	41	...	41	...	6287
	Check	135	31	...	31	...	2759
	Gas ± Check %.	+159.3	+32.3		+32.3		+127.8
II	Gas	524	35	351	35	173	9506
	Check	285	32	211	32	74	5342
	Gas ± Check %.	+83.9	+9.4	+66.4	+9.4	+133.8	+77.9
III	Gas	458	29	235	29	223	.....
	Check	326	30	196	30	129	.....
	Gas ± Check %.	+40.5	—3.3	+19.9	—3.3	+72.9	
IV	Gas	643	75	416	75	227	8358
	Check	454	69	327	69	127	6432
	Gas ± Check %.	+41.6	+8.7	+27.2	+8.7	+78.7	+29.9
Total	Gas	1975	180	...	180	...	.....
	Check	1200	162	...	162	...	.....
	Gas ± Check %.	+64.6	+11.1		+11.1		

The superiority of the gas-treated plants was shown at every point. They produced, as compared with their competitors, 10 percent more leaves, two-thirds as much again foliage, longer and heavier leaf stalks and much greater leaf areas. These increases, however, can hardly be attributed to the production of thicker leaves, for a comparison of leaf areas and weights shows that the data correlated almost exactly, that in other words, the increased weights were due to the production of larger areas and not of thicker tissues.

The roots of a single gassed plant, kept alive for six weeks as compared with those of a check similarly kept growing, weighed one-third more.

(*b*) CHEMICAL ANALYSES

The usual chemical analyses were made of the several cuttings and of the roots, from which the calculation of the composition of the entire crop above and below ground has been computed. The following tables set forth the chemical composition and the constituent yields.

ABLE XVII. SWISS CHARD: CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS; ENTIRE PLANTS AND SEPARATES

	Green weight	Dry matter	Dry matter	100 parts dry matter contain: Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
	grams	%	grams	%	%	%	1:	grams	grams	grams
Successive Leaf Cuttings										
Gas	350	5.14	18	26.90	35.23	37.87	1.07	4.84	6.34	6.82
Check	135	5.88	7.9	22.90	33.63	43.47	1.29	1.81	2.66	3.43
Gas ± Check %	+59.3		+127.9					+167.4	+138.5	+98.8
I Gas	524	6.06	31.7	24.15	35.75	40.10	1.12	7.65	11.33	12.77
Check	285	6.49	18.2	21.58	35.51	42.91	1.21	3.93	6.46	7.81
Gas ± Check %	+83.9		+74.2					+94.7	+75.4	+63.5
II Gas	458	6.62	30.3	24.39	29.90	45.71	1.53	7.39	9.05	13.85
Check	326	7.76	25.3	22.92	30.32	46.76	1.54	5.79	7.67	11.83
Gas ± Check %	+40.5		+19.8					+27.6	+17.9	+17.2
V Gas	643	7.48	48.1	20.96	29.25	49.79	1.70	10.09	14.07	23.95
Check	454	7.99	36.3	24.69	30.94	44.37	1.43	8.97	11.23	16.10
Gas ± Check %	+41.6		+32.5					+12.5	+25.4	+48.8
Roots										
Gas	163	11.14	18.2	17.16	18.40	64.44	3.50	3.12	3.35	11.72
Check	117	13.30	15.5	17.56	18.40	64.03	3.48	2.72	2.86	9.92
Gas ± Check %	+39.3		+17.4					+16.4	+17.5	+18.2
Entire Plant										
Gas	2138	6.84	146.3	22.63	30.16	47.21	1.56	33.09	44.14	69.11
Check	1317	7.83	103.2	22.52	29.94	47.54	1.59	23.22	30.89	49.09
Gas ± Check %	+62.2		+41.7					+42.5	+43	+40.8

It is to be noted:

(1) That the gassed plants grew more and heavier leaves, containing more dry matter; that the gains were more pronounced in the earlier cuttings than the later ones but always were in evidence, and that even the roots responded.

(2) That all constituents responded in increased yields, and very evenly, the carbohydrates showing no more gains than the other constituents, thus differing from some of the other plants under trial. Indeed, the computed analyses of the entire plant on the dry matter basis were so closely alike that the figures might well serve for duplicate determinations of the same sample.

(3) The gassed plants were more succulent than those not thus treated, due doubtless to the greatly increased growth forced by the carbon dioxid dosage. This effect was clearly seen in each cutting.

In brief, it may be said that Swiss chard responds to gas treatment

by increased growth of a more succulent character and of unchanged chemical composition.

VI. INFLUENCE ON FRUIT CROPS

1. STRAWBERRIES

The small stature of the strawberry plant and its abundant fruitage adapt it especially well to the study of the effect of carbon dioxid dosage on fruit production. The plants were grown in the greenhouse in the winter and were necessarily submitted to the usual pre-forcing conditions of rest and drought before they were used. The same size and kind of boxes were employed as for other plants. Only the bisexual varieties were chosen in order to avoid the uncertainties of pollination and fertilization which might occur with unisexual forms. Pollination was effected by the use of uncontaminated camel's hair brushes, the pollen being transferred each day throughout the blossoming period.

(*a*) PHYSICAL ANALYSES

The comparisons were made on the basis of number and weight of foliage and fruit, seven trials being made.

TABLE XVIII. STRAWBERRIES: PHYSICAL ANALYSES

		Leaves		Petioles		Berries	
		Number	Weight	Average length	Weight	Number	Weight
				gr.	cm.	gr.	gr.
(1) 12/21/14-4/16/15	Gas	204	78.9	6.2	122	477.5	25
96 days, 39% sunshine	Check	138	42.4	5.3	53	204.9	15
6 and 6 plants	Gas ± Check %	+47.8	+86	+16.9	+130.2	+133	+6
(2) 1/4-4/15/15	Gas	232	127.7	7.7	106	519.4	46
112 days, 48% sunshine	Check	218	114.2	7.9	63	265.7	41
6 and 6 plants	Gas ± Check %	+6.4	+11.8	—2.5	+68.3	+95.5	+
(3) 3/10-5/10/15	Gas	51	27.2	3	42	178.1	
62 days, 52% sunshine	Check	64	28.3	2.8	33	130.7	
6 and 6 plants	Gas ± Check %	—20.3	—4	+7.1	+27.3	+36.3	—
(4) 3/20-5/24/15	Gas	79	143.9	9.9	58	172.6	41
65 days, 48% sunshine	Check	62	92.2	7.4	31	94.4	
6 and 6 plants	Gas ± Check %	+27.4	+56.1	+33.7	+87.1	+82.9	+8
(5) 3/22-6/9/15	Gas	173	116.2	4.9	206	911.8	
79 days, 53% sunshine	Check	156	100.6	4.9	155	660.3	39
12 and 12 plants	Gas ± Check %	+10.9	+15.5	0	+32.9	+38.1	+3
(6) 3/22-7/8/15	Gas	103	23.5	4.3	47	228.5	5
108 days, 51% sunshine	Check	73	52.5	4.8	32	98.7	8
3 and 3 plants	Gas ± Check %	+41.1	—55.2	—10.5	+46.9	+131.6	—41
(7) 3/22-7/8/15	Gas	71	28.2	4	68	423.4	6
108 days, 51% sunshine	Check	59	27.5	4.3	72	303.5	5
3 and 3 plants	Gas ± Check %	+20.3	+2.6	—7	—5.6	+39.5	+12

The results are positive and emphatic in favor of the treatment. In every instance the fruitage of the treated plants weighed more than that of the checks. In three instances the gain was ⅜, in two from 5/6 to 19/20 and in two the gain was 1⅓. The average gain was 80 percent—a striking result. The number of fruit were increased in six of the seven trials, the average numerical increase being 55 percent.

In general the treated plants were the more foliaceous, the weight of the leaves increasing as a rule more than their number, which means that the treated plants generally bore more and either larger or thicker leaves.

The firmness, sweetness and palatability of the berries grown on the competing lots seemed identical. No chemical analyses were made of the plants or fruit.

In brief, carbon dioxid dosage increased the number and weight of strawberry leaves to some extent, and decidedly increased the number and weight of the fruit.

VII. INFLUENCE ON FLOWER PRODUCTION

Cyclamens and nasturtiums were selected for experimentation on flower production, for the reason that these plants were typical representatives of the floricultural group and likewise best met the exigencies of space.

1. CYCLAMENS

The cyclamen is small of stature and extensive in its flowering habit, continuing its blossoming period over a considerable period of time, thus affording an abundant opportunity for studying the influence of carbon dioxid on flower production. The flowers are borne terminally on single scapes and the stalks were capable of easy measurement and weight. Cyclamens usually flower in about 15 months from seed. A fleshy food-storing organ known as a corm is developed, mostly below the surface of the soil, during the interregnum between seed germination and flower production. It was the presence of this corm, which is common among flowering plants, and its relation to the plant that gave special interest to the cyclamen trials. The question was: Will a plant that normally stores food in anticipation of its needs in the flowering period be materially benefited by exposure to an atmosphere heavily charged with carbon dioxid?

A large number of plants was grown in the greenhouses for several months prior to the inauguration of the trial from which lots the experimental plants were carefully selected as to size, vigor and uniformity of development. Treatment began as they approached the flowering period. The competing lots were compared on the basis of foliage, flower and corm development.

(*a*) PHYSICAL ANALYSES

TABLE XIX. CYCLAMEN: PHYSICAL ANALYSES

	Leaves		Leafstalks		Flowers	Flower stalks	Corms
	Number	Weight grams	Weight grams	Length cm.	number	length cm.	weight grams
(1) October 15, 1913—April 17, 1914. 184 days, 35 percent sunshine. 3-3 tubers.							
Gas	181	163	78	1529	101	1707	132.2
Check	172	154	96	1670	47	853	67.4
Gas ± Check %	±4.3	+5.8	—18.7	—8.5	+114.9	+100.1	+96.1
(2) October 29, 1914—March 19, 1915. 140 days, 41 percent sunshine. 4-4 tubers.							
Gas	274	577	269	3321	78	1679	54.3
Check	352	646	371	5361	80	1760	37.3
Gas ± Check %	—22.2	—20.3	—27.5	—38	—2.5	—4.6	+45.6
(3) November 9, 1914—March 20, 1915. 131 days, 43 percent sunshine 8-8 tubers.							
Gas	344	778	328	3467	152	2563	755
Check	272	525	289	3223	128	2230	576
Gas ± Check %	+26.5	+48.2	+13.5	+7.6	+18.8	+14.9	+31.1

It was a matter of much speculation at the outset as to how, if at all, cyclamen would respond to superabundance of carbon dioxid. There were three possibilities: increased flower production, greater vegetative growth, increased weight of corms. The expected increase in flower production did not occur, except in the first trial. Greater vegetative growth in cyclamen could be manifested only in the leaf structures, and their numbers and weight were increased in the first and third trials. The storage portion chiefly benefited. In every instance the corms of the treated plants were much heavier, being from one-third heavier to twice as heavy as the corms of the normally grown plants. In trial 3 the tubers were of extra size at the start, hence the marked increase in weight of both sets at the time of harvest.

(*b*) CHEMICAL ANALYSES

Analyses were made of the two 1915 crops, leaves, leaf stalks, flower stalks and corms being handled as a whole, with results as shown in the following tables:

ABLE XX. CYCLAMEN: ENTIRE PLANT; CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS

	Dry matter	Dry matter	Green weight	100 parts dry matter contain			Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
	Dry matter	Dry matter	Green weight	Crude ash	Crude protein	Carbohydrates and ether extract	Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
	grams	%	grams	%	%	%	1:	grams	grams	grams
arch 19										
as	1389	17.97	249.6	5.83	9.13	85.04	9.31	14.54	22.78	212.28
heck	1390	14.75	205.1	8.15	11.65	80.20	6.89	16.72	23.90	164.48
as ± Check %	—0.1		+21.7					—13.1	—4.7	+28.9
arch 20										
as	1860	15.71	292.2	6.87	10.76	82.37	7.65	20.07	31.43	240.70
heck	1389	16.04	222.8	7.40	13.05	79.55	6.1	16.49	29.07	177.24
as ± Check %	+33.9		+31.2					+21.7	+8.1	+35.8

It is clear that the gassed plants contained more dry matter than those not so treated, and that the increase was located in the carbohydrate rather than the protein content, as evidenced by the gains column as well as by the ratios. However, while this is scientifically important by way of confirmation of the results secured with edible crops, it has no apparent practical importance except in so far as increased carbohydrate storage may favorably affect the flowering habits of the plants during another season.

2. NASTURTIUMS (*Tropaeolum*)

Dwarf nasturtiums were selected in order that as many plants might be used as possible within a near radius of gas liberation. The carbon dioxid was supplied continuously from the time the plants were put under treatment, which in most instances was about two weeks after germination. The trials extended over two winter seasons and included seven different crops.

(*a*) PHYSICAL ANALYSES

Flower production, the length of flower stalks, the number and weight of leaves, and the total weight of the plants were measured and are presented in the following tables:

TABLE XXI. NASTURTIUMS: PHYSICAL ANALYSES

		Green weight gr.	Leaves number	Weight gr.	Stalks weight gr.	Flowers number
(1) 10/20/13-4/13/14	Gas	2856	2100	473	2382	198
175 days, 35% sunshine	Check	2725	2349	448	2277	112
8 and 8 plants	Gas ± Check %	+4.8	—10.6	+5.6	+4.6	+76.8
(2) 6/30-11/6/14	Gas	1666	3308	319	1347	10
128 days, 49% sunshine	Check	1087	2260	232	855	5
7 and 7 plants	Gas ± Check %	+53.3	+46.4	+37.3	+57.6	+100
(3) 9/10-12/29/14	Gas	1731	2853	241*	1385*	183
110 days, 39% sunshine	Check	1493	2475	251*	1165*	32
4 and 4 plants	Gas ± Check %	+16	+15.3	—4	+18.9	+471.9
(4) 10/15-12/29/14	Gas	1872	656	232	1640	20
75 days, 31% sunshine	Check	1570	549	272	1299	0
4 and 4 plants	Gas ± Check %	+19.2	+19.5	—14.7	+26.6	Infinity
(5) 10/28-12/29/14	Gas	2134	595	336	1799	13
62 days, 30% sunshine	Check	1343	432	229	1114	2
4 and 4 plants	Gas ± Check %	+59	+37.3	+46.5	+62.5	+550
(6) 12/14/14-6/7/15	Gas	3120	5300	361	2759	1787
174 days, 50% sunshine	Check	2113	4014	279	1834	597
4 and 4 plants	Gas ± Check %	+47.7	+32	+29.2	+50.4	+199.3
(7) 12/18/14-6/8/15	Gas Check.....	3063	Too dry to count and			1056
171 days, 49% sunshine	Check	2110	weigh accurately?			868
4 and 4 plants	Gas ± Check %	+45.2				+21.7

*See footnote to table XXII, p. 49.

The results, in contradistinction to those secured with the cyclamens, were positive, consistent and emphatic. When gas was supplied the gross weights were always greater, more flowers bloomed, the stalks weighed more, and with one exception, there were more leaves, though usually somewhat smaller ones. In five of the seven trials the gassed plants began to bloom before their mates. The early harvests in trials 4 and 5 were necessitated by the low temperature in the house caused by an intense cold wave.

(*b*) CHEMICAL ANALYSES

Chemical analyses were made of five of the seven lots with results as follows, expressed as percentages and in terms of weights of ingredients. The flowers being cut from time to time were not included in the samples for analyses, nor do they figure in the "green weight," which term means in each case the total weight of leaves and stalks, not including flower stalks or flowers.

ABLE XXII. NASTURTIUMS: ENTIRE PLANT; CHEMICAL ANALYSES AND WEIGHTS OF INGREDIENTS

	Dry matter	Dry matter	Dry matter	100 parts of dry matter contain			Ratio	Crude ash	Crude protein	Carbohydrates and ether extract
				Crude ash	Crude protein	Carbohydrates and ether extract				
	grams	%	grams	%	%	%	1:	grams	grams	grams
2) Gas	1666	7.90	13.16	18.74	21.30	59.96	2.82	24.6	27.9	79.1
Check	1087	8.36	90.8	21.62	20.95	57.43	2.74	19.6	18.9	52.3
Gas ± Check %.	+53.3		+44.9					+25.5	+47.6	+51.2
4) Gas	1872	6.72	125.6	17.08	24.32	58.60	2.42	21.5	30.5	73.6
Check	1570	6.32	99.3	17.19	25.25	57.56	2.28	17.1	25.1	57.1
Gas ± Check %.	+19.2		+25.5					+25.7	+21.5	+28.9
5) Gas	2134	7.19	153.5	17.11	23.81	59.08	2.48	26.3	36.6	90.6
Check	1343	6.62	89	17.37	26.79	55.84	2.08	15.5	23.9	49.6
Gas ± Check %.	+57.6		+72.5					+69.7	+54	+82.7
3) Gas	1626*	9.07	147.4	18.54	19.73	61.73	3.13	27.4	29.1	90.9
Check	1416*	8.56	121.2	18.93	21.23	59.84	2.82	23	25.7	72.5
Gas ± Check %.	+14.8		+21.7					+19.1	+13.2	+25.4
6) Gas	3120	16.22	506.5	18.18	17.60	64.22	3.65	92.1	89.3	325.1
Check	2113	15.22	321.6	18.67	18.07	63.26	3.52	60	58.1	203.5
Gas ± Check %.	+47.7		+57.3					+53.3	+53.7	+59.8
7) Gas	3063	14.04	429	18.64	18.92	62.44	3.3	79.9	81.1	268
Check	2110	13.15	277.3	18.40	18.17	63.43	3.48	51.1	50.4	175.8
Gas ± Check %.	+45.2		+54.8					+56.4	+60.9	+52.4

*Weights taken next day after total weights as shown in table XXI; hence the lower gures. The dry matter content, etc., and other percentage data are not affected, except insofar s fermentation caused destruction.

The outcome is striking. Without exception the gassed plants weighed more, contained more dry matter, more ash constituents, more protein and more carbohydrates than those not thus treated. Five out of six of the gassed crops contained larger percentages of dry matter and larger percentages of carbohydrates than did the corresponding checks. As usual, the ratios set forth the carbohydrate storage situation distinctly. It is perfectly clear that the nasturtium plant responds to a superabundance of carbon dioxid, both physically and chemically.

VIII. OVERDOSAGE

Several experiments were conducted both in open and closed boxes in order to ascertain the influence of varying dosages, beans being used for the purpose.

The plants in the closed boxes, which were found ill suited to the purposes of the main trials for reasons heretofore set forth, were

subjected to definitely measured excessive amounts of the gas generated within the receptacles, being exposed for eight-hour periods daily to the surcharged atmosphere. At the expiration of each period the plants were either removed or were thoroughly aired and kept well ventilated until the next morning. The charging receptacles were screened with cheese cloth in order to lessen the heat within and to maintain a tolerable temperature.

The plants thus treated were slow to respond. Injuries were not apparent for several days. In no instance did anything more than a dwarfing effect occur within six days. In comparison with the untreated crop the heavily gassed plants exhibited the following progressive stages of injury:

They were first conspicuously dwarfed, growth being almost inhibited; then they became pale, the characteristic green color being much lighter; they then became conspicuously unthrifty. After about seven days small faint discolored and blistered areas appeared, which soon developed in size and increased in number until nearly the whole leaf became affected. The foliage soon dropped, wilted and often totally collapsed. The new leaves and tender growths proved most susceptible and first succumbed, the larger leaves and older stems being less readily affected.

Carbon dioxid was used in closed boxes in amounts varying from 7.6 liters as a minimum to 47.6 liters as a maximum dosage. In terms of percentage this meant from 4 to 25 percent of the enclosed air or, in other words, the carbon dioxid content of the air varied from 1 part in 25 to 1 part in 4. No damage was done by the daily application of 7.6 liters for a 10-day period; in fact the treated plants were as large and as thrifty as were the untreated. A 15-liter dosage—equivalent to an 8 percent daily charge for a 36-day period—proved beneficial. The total weight was 2 percent greater, weight of pods 60 percent greater than those of the check plants. A 19-liter dosage, equivalent to a 10 percent daily charge for 20 days, proved harmful. The untreated plants as compared with the gassed ones weighed 30 percent more, their leaves numbered 19 percent more, weighed 31 percent more, and measured 47 percent more in area. When a 29-liter dosage was used, which was equivalent to an 18 percent carbon dioxid atmospheric content, not only was the growth checked and dwarfed but the margins of the leaves were scorched. An application of 38 liters—a 20 percent charge for a 16-day period—proved disastrous. Much injury was inflicted, the leaves collapsing before the trial closed. The

maximum dosage of 47.6 liters, giving an atmosphere containing 25 percent carbon dioxid, caused injury on the second day and accumulative injuries thereafter. An 8 percent atmosphere proved to be the optimum for beans in closed boxes.

There seems little if any danger of over-dosage when open boxes are used. Even the 347-liter dosage for beans referred to elsewhere did not injure the plants. The gas disperses so freely into the air that it is scarcely possible for it to accumulate in injurious amounts. It was noted, however, that if the delivery tube came into contact with the foliage, injury was likely to occur. It was found safer to liberate larger doses of gas a few inches from the plant.

IX. OPTIMUM DOSAGE

What is the optimum dosage? The results of trials with beans and lettuce afford some data contributing to an answer to this question. The tests were conducted in the greenhouse and in the garden, the plants being grown in open boxes. Lettuce and beans were chosen for the express purpose of comparing two very dissimilar plants. Lettuce is a compact, low stature, cool temperature plant, while the bean is loosely disposed, relatively high in stature, and warm in its temperature requirements. These differences and others, such as varying fertilizer requirements and unlikeness in chemical composition, might well be expected to result in differences in optimum dosages. Indeed there is little reason for assuming that the optimum needs are the same for all groups of plants.

Five tests were made with beans, and nine with lettuce, the gaseous dosage varying in amounts from nil to 348 liters. As in the regular trials the gas was delivered gradually for eight hours daily. The amount of delivered gas was definite, but the volume retained was variable for the reason that slight currents of air modified the rate of diffusion. Moreover, the temperature and humidity changes incident to greenhouse and garden culture affect to some extent the rate of gaseous dispersion. The gas boxes were aired out each night by removing one glass side and were charged afresh each morning, Sundays included. It is to be noted that daily at the start the content of the air was nil and that it gradually increased as the day advanced, reaching doubtless its maximum late in the afternoon owing to the weight of the carbon dioxid as compared with that of air.

The results of the several trials with beans and lettuce appear in the following tables which set forth both physical and chemical analyses.

TABLE XXIII. BEANS: OPTIMUM DOSAGE; OPEN BOXES

Amount of soda	Amount of gas	Number of plants	Number of leaves	Weight of leaves	Number of pods	Weight of empty pods	Number of seeds	Weight of seeds	Weight of stalks	Total weight of plant
grams	liters			grams		grams		grams	grams	grams
(1) July 24-September 27, 1915. 65 days, 48 percent sunshine.										
400	116	18	592	482	126	526	464	465	349	1822
300	87	18	562	384	119	451	389	397	301	1533
200	58	18	649	475	114	458	414	397	371	1701
100	29	18	584	447	111	450	387	380	327	1604
50	14.5	18	497	349	95	353	303	296	247	1245
Check		18	510	296	92	321	365	251	223	1091
(2) August 23-November 3, 1916. 72 days, 52 percent sunshine.										
400	116	10	787	508	125	557	286	315	417	1797
300	87	10	502	422	112	452	276	304	300	1478
200	58	10	516	342	102	297	232	306	247	1192
100	29	10	525	255	87	246	245	265	206	972
50	14.5	10	404	219	84	235	196	225	178	857
Check		10	414	307	83	267	177	185	236	995
(3) June 12-August 4, 1915. 53 days, 52 percent sunshine.										
400	116	12	679	618	172	502	428	247	327	1694
300	87	12	614	598	155	443	459	201	344	1586
200	58	12	742	635	173	518	431	249	364	1766
100	29	12	626	582	129	398	360	217	270	1467
50	14.5	12	666	591	110	301	322	151	270	1313
Check		12	701	716	136	462	466	301	324	1803
(4) January 25-April 12, 1916. 78 days, 50 percent sunshine										
1200	348	13	294	149	45	209	138	166	92	616
1000	290	13	442	299	86	513	194	127	170	1109
800	232	13	477	233	70	387	178	140	132	892
600	174	13	309	185	49	247	128	149	88	669
400	116	13	264	162	42	176	114	139	88	565
No check crop grown.										
(5) December 20, 1916-May 4, 1917. 135 days, 47 percent sunshine										
1200	348	15	538	461	53	274	165	234	250	1219
1000	290	15	703	597	70	377	60	171	259	1404
800	232	15	627	465	69	448	200	194	247	1354
600	174	15	494	418	62	222	182	274	185	1099
400	116	15	505	360	47	291	138	138	176	965
No check crop grown.										

TABLE XXIV. BEANS: AVERAGE PER PLANT OPTIMUM DOSAGE; OPEN BOXES

Amount of soda	Amount of gas	Number of plants	Number of leaves	Weight of leaves	Number of pods	Weight of empty pods	Number of seeds	Weight of seeds	Weight of stalks	Total weight of plant
grams	liters			grams		grams		grams	grams	grams
(1) July 24-September 27, 1915. 65 days, 48 percent sunshine.										
400	116	18	32.9	26.8	7	29.2	25.8	25.8	19.4	101.2
300	87	18	31.2	21.3	6.6	25.1	21.6	22.1	16.7	85.1
200	58	18	36.1	26.4	6.3	25.4	23	22.1	20.6	94.5
100	29	18	32.4	24.8	6.2	25	21.5	21.1	18.2	89.1
50	14.5	18	27.6	19.4	5.3	19.6	16.8	16.4	13.7	69.2
Check		18	28.3	16.4	5.1	17.8	20.3	13.9	12.4	60.6
(2) August 23-November 3, 1915. 72 days, 52 percent sunshine.										
400	116	10	78.7	50.8	12.5	55.7	28.6	31.5	41.7	179.7
300	87	10	50.2	42.2	11.2	45.2	27.6	30.4	30	147.8
200	58	10	51.6	34.2	10.2	29.7	23.2	30.6	24.7	119.2
100	29	10	52.5	25.5	8.7	24.6	24.5	26.5	20.6	97.2
50	14.5	10	40.4	21.9	8.4	23.5	19.6	22.5	17.8	85.7
Check		10	41.4	30.7	8.3	26.7	17.7	18.5	23.6	99.5
(3) June 12-August 4, 1915. 53 days, 52 percent sunshine										
400	116	12	56.6	51.5	14.3	41.8	35.7	20.6	27.3	141.2
300	87	12	51.2	49.8	12.9	36.9	38.3	16.7	28.7	132.2
200	58	12	61.8	52.9	14.4	43.2	35.9	20.8	30.3	147.2
100	29	12	52.2	48.5	10.8	33.2	30	18.1	22.5	122.3
50	14.5	12	55.5	49.3	9.2	25.1	26.8	12.6	22.5	109.5
Check		12	58.4	59.7	11.3	38.5	38.8	25.1	27	150.3
(4) January 25-April 12, 1916. 78 days, 50 percent sunshine.										
1200	348	13	22.6	11.5	3.5	16.1	10.6	12.8	7.1	47.4
1000	290	13	34	23	6.6	39.5	14.9	9.8	13.1	85.3
800	232	13	36.7	17.9	5.4	29.8	13.7	10.8	10.2	68.6
600	174	13	23.8	14.2	3.8	19	9.8	11.5	6.8	51.5
400	116	13	20.3	12.5	3.2	13.5	8.8	10.7	6.8	43.5
No check crop grown.										
(5) December 20, 1916-May 4, 1917. 135 days, 47 percent sunshine.										
1200	348	15	35.9	30.7	3.5	18.3	11	15.6	16.7	81.3
1000	290	15	46.9	39.8	4.7	25.1	4	11.4	17.3	93.6
800	232	15	41.8	31	4.6	29.8	13.3	12.9	16.5	90.3
600	174	15	32.9	27.9	4.1	14.8	12.1	18.3	12.3	73.3
400	116	15	33.7	24	3.1	19.4	9.2	9.2	11.7	64.3
No check crop grown.										

TABLE XXV. BEANS: DRY MATTER PERCENTAGES

Amount of soda grams	Amount of gas liters	Leaves	Stalks	Pods	Seed	Entire plant
(1) July 24-September 27, 1915. 65 days, 48 percent sunshine.						
400	116	15.73	16.72	12.12	38.50	21.22
300	87	19.00	17.96	12.79	39.50	23.00
200	58	18.75	17.99	13.55	38.40	22.49
100	29	17.05	15.33	12.46	37.54	21.10
50	14.5	17.31	17.53	13.06	37.64	21.58
Check		18.95	17.48	12.66	37.04	21.97
(2) August 23-November 3, 1916. 72 days, 52 percent sunshine.						
400	116	16.09	18.83	12.35	37.34	19.28
300	87	14.65	17.81	15.29	37.61	20.20
200	58	16.18	17.57	13.78	41.17	22.28
100	29	18.03	18.49	16.52	41.03	24.01
50	14.5	15.66	18.73	17.44	38.98	22.91
Check		17.19	21.21	17.52	39.30	23.35
(3) June 12-August 4, 1915. 53 days, 52 percent sunshine.						
400	116	20.24	17.70	11.76	32.36	18.73
300	87	24.93	16.09	11.03	33.27	18.75
200	58	28.75	16.60	10.56	32.82	19.43
100	29	25.87	17.15	11.00	34.43	19.97
50	14.5	23.20	15.74	10.56	33.72	19.73
Check		18.06	15.51	11.87	36.03	19.34
(4) January 25-April 12, 1916. 78 days, 50 percent sunshine.						
1200	348	16.04	21.92	15.83	38.24	22.83
1000	290	14.69	21.02	13.39	26.16	16.35
800	232	15.56	21.76	14.21	31.32	18.37
600	174	13.14	20.61	14.66	35.18	19.60
400	116	14.22	21.66	16.94	38.95	22.35
(5) No chemical analyses made.						

TABLE XXVI. OPTIMUM DOSAGE FOR LETTUCE

Amount of soda grams	Amount of gas liters	Number of plants in test	Number of leaves	Weight grams	Average weight per plant grams	Dry matter %
(1) November 12-January 24, 1916. 75 days, 47 percent sunshine.						
400	116	9	297	800	88.9	4.28
300	87	9	259	521	57.9	4.39
300	58	9	301	815	90.6	4.23
100	29	9	333	910	101.1	4.26
50	14.5	9	256	427	47.4	5.19
Check	Check	9	278	412	45.8	....
(2) November 13-December 28, 1916. 45 days, 29 percent sunshine.						
400	116	8	109	353	44.1	....
300	87	8	106	279	34.9	....
200	58	8	94	133	16.6	....
100	29	8	87	179	22.4	....
50	14.5	8	70	83	10.4	....
(3) February 1-March 24, 1916. 51 days, 50 percent sunshine.						
1200	348	2	23	28	14	5.81
1000	290	2	33	139	69.5	5.48
800	232	2	29	103	51.5	5.66
600	174	2	98	99	49.5	5.49
(4) March 24-April 29, 1916. 36 days, 50 percent sunshine.						
1200	348	2	56	272	136	7.49
1000	290	2	44	314	157	5.15
800	232	2	51	310	155	5.28
600	174	2	45	225	112.5	6.01
(5) April 4-May 22, 1916. 48 days, 43 percent sunshine.						
1200	348	2	71	195	97.5	....
1000	290	2	64	229	114.5	....
800	232	2	77	210	105	....
600	174	2	61	193	96.5	....
400	116	2	53	98	49	....
(6) September 18-November 6, 1916. 48 days, 52 percent sunshine.						
1200	348	8	179	618	77.2	....
1000	290	8	151	390	48.8	....
800	232	8	169	478	59.8	....
600	174	8	164	493	61.6	....
400	116	8	126	310	38.8	....
(7) April 1-May 8, 1916. 38 days, 41 percent sunshine.						
1200	348	8	155	500	62.5	5.50
1000	290	8	131	375	46.9	6.30
800	232	8	151	413	51.6	6.33
600	174	8	138	367	45.9	6.33
400	116	8	140	654	81.8	5.74
(8) June 28-August 8, 1916. 41 days, 60 percent sunshine.						
1200	348	6	162	723	120.5	3.72
1000	290	6	142	704	117.3	3.27
800	232	6	148	563	93.8	4.01
600	174	6	161	737	122.8	3.62
400	116	6	139	705	117.5	3.18
(9) July 26-September 16, 1916. 53 days, 57 percent sunshine.						
1200	348	8	129	906	113.3	....
1000	290	8	127	827	103.4	....
800	232	8	122	593	74.1	....
600	174	8	138	845	105.7	....
400	116	8	128	1104	138.8	....

These trials do not clearly indicate an optimum for beans. In a general way the larger dosages—400 grams carbonate of soda, equivalent to 116 liters of gas—outranked their competitors in the first three trials. It should be noted that the check in the third trial was composed of a lot of unusually thrifty plants which were not, as were all the gassed lots in this particular experiment, infested with red spider. Their escape from insect attack probably accounts for the relatively high yield. Even including this result, however, the general outcome is as has just been stated, namely, that the larger the dosage, up to 116 liters, the larger the yields.

When, however, two further trials were made in which the former maximum dosage became the minimum of a new series of five, in which a new maximum thrice as great as the former was employed, the outcome was not the same. The 116-liter treatment, heretofore the best, was distinctly outclassed by each of its competitors. It would seem as if the 1200 gram—348 liter dosage was too much, for the results as measured in terms of weight were less favorable than those secured when amounts of gas from two-thirds to five-sixths as large were administered. Furthermore, it was observed in a trial not herein reported that a 2000 gram-580 liter dosage seriously injured the crop. No damage was done so far as can be observed when not to exceed 1200 grams were used.

Nothing outstanding appears as regards the dry matter percentages in the whole plant or the separates. Apparently the heavy gas dosages did not notably affect the dry matter contents of the bean plant.

So far as the lettuce is concerned, it is perfectly clear in the light of the results secured in the last seven trials shown in the table, that the two earlier ones, in which a maximum dosage of 116 liters was employed, really have little bearing on the question now under discussion, except in so far as they indicate that the lettuce plants given the larger dosage did as well as or better than those subjected to smaller amounts of gas. The last seven trials seem on the whole to indicate that the use of the larger amounts ranging from 800 to 1200 grams (232-348 liters) was correlated with the larger yields. This is especially true if the utterly anomalous results secured in the third trial on the 1200-gram dosage are disregarded. Whether lettuce plants would stand more than a 1200-gram dosage, who knows? So far as these trials indicate, it would seem as if a usage of 1000 to 1200 grams approximates optimum conditions. The optimum for lettuce is clearly much higher than that for beans.

JULY, 1918 NOV 13 1922 BULLETIN 212

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

THIRTY-FIRST ANNUAL REPORT

1917-1918

BURLINGTON
FREE PRESS PRINTING COMPANY
1918

THE BOARD OF CONTROL

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THE PRESIDENT, DEAN and DIRECTOR, THE DIRECTOR OF THE EXTENSION SERVICE, COMMISSIONER OF EDUCATION and COMMISSIONER OF AGRICULTURE, *Ex-officio.*

THE OFFICERS OF THE STATION

J. L. HILLS, Sc. D., Director.
F. A. RICH, V. S., M. D., Veterinarian.
C. H. JONES, M. Sc., Chemist.
M. B. CUMMINGS, Ph. D., Horticulturist.
B. F. LUTMAN, Ph. D., Plant Pathologist.
G. P. BURNS, Ph. D., Botanist.
H. B. ELLENBERGER, Ph. D., Animal and Dairy Husbandman.
A. K. PEITERSEN, Ph. D., Assistant Botanist.
L. H. FLINT, M. Sc., Assistant Botanist.
JENNIE L. ROWELL, B. S., Assistant Chemist.
G. F. ANDERSON, Assistant Chemist.
J. B. NORTON, M. Sc., Assistant Horticulturist.
H. E. BARTRAM, B. S., Assistant Plant Pathologist.
H. F. MOORE, A. B., Assistant Veterinarian.
W. H. CROCKETT, Editor.
ALEXANDER PARKS, Gardener.
WINIFRED B. KENNEDY, Stenographer.
MAY O. BOYNTON, Ph. B., Librarian.
GUY W. BAILEY, A. B., Treasurer.

☞ Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞ Address all communications concerning station matters not to individual officers but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street. University farm and buildings are on the Williston road, adjoining the University grounds on the east.

ANNOUNCEMENT

The Vermont Agricultural Experiment Station is organized under an act of the General Assembly of 1886 and acts of Congress approved March 2, 1887, and March 16, 1906. Subsequent state legislation has placed upon the Station the duties pertaining to: (1) the inspection of commercial fertilizers; (2) the inspection of commercial feeding stuffs; (3) the inspection and certification of Babcock glassware and operatives; (4) the inspection of agricultural seed. Its financial support is derived from congressional funds and from state appropriations used in feeding stuffs, agricultural seed and fertilizer inspection.

The Station is *not* prepared:

1. To identify fruits, grasses, weeds and other plants, fungus diseases, insect pests, etc., or to advise and assist by correspondence, touching matters pertaining to agriculture, horticulture, plant or animal diseases, insect injuries, etc. The service of this character which the Station gratuitously rendered for nearly 25 years is now performed by the Agricultural Extension Service of the College of Agriculture of the University.

2. To identify or analyze minerals, drinking water, human food or drugs. Minerals should be sent to the State Geologist, Burlington. Waters, human foods, drugs and poison cases should be referred to the State Board of Health Laboratory, Burlington.

3. To analyze fertilizers, feeding stuffs for domestic animals, seeds, milk and other dairy products, soils or agricultural materials and products in general as in former years. This free service, performed without charge and without appropriation for 30 years and furnished without charge by no other Station in the country, has been suspended by vote of the Station Board of Control. The names and addresses of reliable commercial analysts will be furnished to such as may be interested.

FINANCIAL REPORTS FOR THE FISCAL YEAR ENDING June 30, 1918

FOR THE HATCH AND ADAMS FUNDS

To receipts from the Treasurer of the United States, as per appropriation for fiscal year ending June 30, 1918, as per acts of Congress approved March 2, 1887, and March 16, 1906	Hatch	Adams
	$15,000 00	$15,000 00
By Salaries	8,925 72	7,964 14
" Labor	1,311 60	3,170 55
" Publications	31 00	.....
" Postage and stationery	339 15	52 69
" Freight and express	123 43	20 12
" Heat, light, water and power	1,286 55	66 78
" Chemicals and laboratory supplies	246 61	387 16
" Seeds, plants and sundry supplies	503 62	254 03
" Fertilizers	2 50	34 50
" Feeding stuffs	314 83	1,389 35
" Library	38 50	6 01
" Tools, machinery and appliances	206 84	7 77
" Furniture and fixtures	251 97	12 10
" Scientific apparatus and specimens	334 50	415 58
" Live stock	.....	546 74
" Traveling expenses	313 18	217 03
" Contingent expenses	20 00	.....
" Buildings and land	750 00	455 45
Total	$15,000 00	$15,000 00

FOR THE FERTILIZER CONTROL, FEEDING STUFFS INSPECTION, AGRICULTURAL SEED INSPECTION AND CREAMERY INSPECTION FUNDS

State appropriation for 1918-19 (No. 58 of 1917, Sec. 33)		$4,150 00
To residue state appropriation for 1917-18 (No. 58 of 1917, Sec. 33)		173 72
To balance on hand last report (creamery inspection)	$ 35 68	
To receipts from applicants for licenses	38 00	
To receipts for testing Babcock glassware	149 88	
		$ 223 56

	Fertilizer control	Feeding stuffs inspection	Agricultural seed inspection	Creamery inspection
By Salaries	$1,212 82	$	$ 160 00	$ .....
" Labor	271 02	14 70	69 70	184 00
" Publications	28 80	18 07	.....	.....
" Postage and stationery	13 37	.....	16 86	6 00
" Freight and express	14 33	.....	.....	1 78
" Heat, light, water and power	81 50	.....	.....	.....
" Chemicals and laboratory supplies	178 23	27 90	.....	.....
" Sundry supplies	.....	.....	13 28	12 53
" Tools, implements and appliances	.....	.....	20 91	.....
" Traveling expenses	440 60	70 42	75 00	.....
Unexpended balance	.....	.....	.....	19 25
	$2,240 67	$ 131 09	$ 355 75	$ 223 56

REPORT OF THE DIRECTOR

JOSEPH L. HILLS

The present report covers the work of the Station during the fiscal year July 1, 1917 to June 30, 1918.

PUBLICATIONS

Two bulletins and the thirtieth annual report, aggregating 000 pages of printed matter, have been issued during the year, a smaller number than have ever been printed since the Station was founded. Several manuscripts, some completed and some in process, are in hand. The published matter includes:

July, No. 208, Thirtieth Annual Report 1916-1917 (issued in bulletin form), by J. L. Hills—16 pages.

September, No. 209, The Cost of Producing Market Milk in 1916-17 on 212 Vermont farms, by G. F. E. Story and W. J. Tubbs—24 pages.

The more technical publications are issued in editions of relatively small size, the more popular bulletins, in the past, in larger editions. Only one set by number is issued, notice usually being given on the title page of the more popular issues of the existence and nature of technical numbers not generally distributed. The report consists of general business statements.

THE STATION BOARD OF CONTROL

The Station Board of Control which has consisted of three persons —for several years four or five—since 1886, was abrogated as a separate board by revision of the Statutes on February 1, 1918, its duties being turned over to the Executive Committee of the University Trustees. There was then retired from direct relationship to the Experiment Station one who had served for more than 31 years. It seems entirely fitting that a brief notice of this fact be included here.

Ebenezer Jalls Ormsbee of Brandon was Governor of Vermont when the Experiment Station was established by legislative enactment, November 24, 1886. He was chosen by the Trustees shortly after that date as one of the "two of their number who, with the president (shall) act as a board of control" and at the meeting for organization, January 14, 1887, was made Secretary and continued as such during four years. For more than 30 years he regularly attended the board meetings and gave of his strength and wisdom in the station's interests. He has been a valued counsellor, an active and

effective trustee. He has out lived all those who, in the years prior to 1911, were associated with him in the governance of this enterprise. His long and unbroken terms of service is believed to be the record, thus far, in the system of American Experiment Stations, and is gratefully remembered by the writer, who has often been endebted to him for sound advice. Governor Ormsbee's relationship to the Board of Trustees still continues—and long may it continue.

CHANGES IN THE STATION STAFF

As indicated in the list of station officers on page 2, several changes have taken place during the year. G. F. E. Story, B. S., Animal and Dairy Husbandman, resigned March 1, to become County Agent of Worcester County, Massachusetts, and was succeeded by H. B. Ellenberger, Ph. D. (Cornell), who was associate from October 15 to March 1. B. A. Chandler, B. S., M. F., Acting Forester, resigned September 1 to enter the employ of Cornell University; L. H. Flint, M. M., Assistant Botanist, resigned in the spring to enter an Officers' Training Camp; H. E. Bartram, B. S., Assistant Plant Pathologist, resigned on December 1, to enter Extension Service employ; no successors being appointed. Hon. C. P. Smith, Treasurer, resigned September 15, being succeeded by Hon. Guy W. Bailey, Comptroller Sundry changes took place in the stenographic force.

THE USES OF THE SEVERAL STATION FUNDS

Hatch fund, $15,000 (Federal): "To conduct original researches or verify experiments"; the publication and distribution of the results of station work; administrative work.

Adams fund, $15,000 (Federal): "Only in paying the necessary expenses of conducting original researches or experiments."

Neither of these funds can be used in indicating the application of research work save by bulletin publication or correspondence, but are employed simply in making the research which lies back of its application. The latter is now provided for in the Agricultural Extension Service. The Adams fund in particular is hedged about by restrictions and used strictly for research.

Fertilizer control fund (State): Solely in the collection and analysis of samples of commercial fertilizers and the publication of the analytical results, together with additional information bearing upon soils, fertilizers and soil management.

Feeding stuffs inspection fund (State): Solely in the collection and analysis of samples of commercial feeding stuffs and the publication of analytical results, together with additional information bearing upon feeds and feeding.

Agricultural seed inspection fund (State): Solely in the collection and analysis of samples of agricultural seed and the publication of the analytical results, together with additional information bearing upon seed and its use.

Creamery inspection fund (License fees, etc.): Solely in determining the ability of test operators and the accuracy of glassware.

(The last three "funds" are included in the flat $4,150 State appropriation—No. 58 of the Acts of 1917, Section 33—from which sum in addition much printing has to be done.)

HATCH AND ADAMS PROJECTS

The following Hatch fund projects have been in hand:

I, II, III, XII. Administration.

IV. Eccentric growth; tree temperature studies (Botany).

V. (1) Soil studies; (2) Work for other station departments; (3) Free analytical work in accordance with P. S. 352 (Chemistry).

VI. Forest reproduction; permanent plot work (Forestry).

VII. Hardwood factor studies (Forestry).

VIII. Quality and quantity studies with squash (Horticulture).

IX. Strawberry runner selection (Horticulture).

X. Cion selection (Horticulture).

XI. Cherry graftage (Horticulture).

XIII. Club-root of cabbage and allied plants (Plant pathology).

XIV. The effect of digestive fluids on spore viability (Plant pathology).

XV. Infectious bovine abortion (Veterinary science).

The following Adams fund projects have been in hand:

I. Forcing plants with carbon dioxid (Horticulture).

IV. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, related questions; begun in 1906. (Dairying; chemistry).

V. The effect of feeding different amounts of digestible protein to cows for a long period; begun in 1906. (Dairying; chemistry).

VI. Study of fundamental processes relative to the storage of sugars and other carbohydrates in wood and in the bark of the sugar maple and other trees; begun in 1909. (Chemistry; forestry).

VII. Maintenance rations for dairy cows, proportion of nutrients used; (a) maintenance, (b) in foetus construction, (c) in milk formation; metabolic requirements of dry cows; begun in 1906. (Dairying).

VIII. The stimulating effect of bordeaux mixture on plants, especially the potato plant; begun in 1909. (Plant pathology).

X. The potato scab; a study of immunity of the advance of the disease during the growth of tubers, etc., the relation of the effects of various chemicals, etc.; begun in 1909. (Plant pathology).

XI. The tolerance of forest trees; begun in 1911. (Botany).

XII. The damping off of seedlings due to fusariums and other organisms; begun in 1908. (Plant pathology).

XIII. Plant breeding studies with *Violoceae* and *Rubus;* begun in 1913. (Botany).

XIV. Sterility of strawberries; begun in 1914. (Horticulture).

XV. Blood complement studies. (Veterinary science).

THE FREE ANALYSIS PRIVILEGE

A state law passed in 1886 requires the Station to "make analyses of all samples received (of agricultural substances and products), provided such analyses will be for the public good * * free of charge to residents of the State" (G. L. 460). At the time when this law was passed an appropriation was provided for its enforcement. When, however, in 1888, federal funds became available for station purposes, the General Assembly of that year withdrew the appropriation but left the obligation. For many years the number of samples received for free analysis was so small that the work was not onerous; but owing to the inauguration of the parcel post system and especially to the activity of the county agents which are now located in 13 counties and are in close relation to more than 96 percent of our farmers, the volume of this work has greatly increased, being probably more than 1,000 per-cent larger than it was 10 to 12 years ago. Several thousand samples are sent in annually for free analysis; samples of all sorts, including soils, fertilizers, feeds, seeds, dairy products and miscellaneous material. Many require but little attention, many necessitate much work.

The federal authorities long protested the use of federal funds for this work, holding that it is illegal; but in the days when its volume was small and the outlay slight they did not make it a serious issue. particularly in view of the fact that the State printed the station publications. However, the sharp curtailing of the edition by the State Board of Control, which necessitates the use of federal funds

for printing purposes, changes the situation and alters the federal attitude, which is clear cut and decisive. It would seem as if the incoming General Assembly should consider the advisability of appropriating a sum of money sufficient to cover the expense incurred in this line of work. Looking at it in a broad way most of these analyses are made in the public interests. It is well that a farmer know what his soil needs; that he have an arbiter in the matter of creamery tests; that he may tell as to the feeds and seeds he contemplates buying. Anything which helps to make the outcome of farming operation more certain and more satisfactory in this agricultural State is in the public interest. However, pending action by the General Assembly, it has become necessary for the Station to take refuge behind the phraseology of the law and to state that "means" do not "permit" it to "make free of charge analyses," etc., and definitely to state that "in (its) judgment" this work is not "for the public good."

DEPARTMENT REPORTS

The following concise satements indicate something of the scope of the work which has been in hand during the past fiscal year:

ANIMAL HUSBANDRY

The following problems have been under survey.

1. *The feeding trials in which varying amounts of protein are being fed to dairy cows* (Adams, V) have shown the striking results and has been, save for a few minor items, closed for good and for all. Manuscript is in process of preparation.

2. *The maintenance requirements of dairy cows* under varying conditions both in regard to lactation and foetal development (Adams, VII) are being studied in a long term experiment. The importance of exercise as a factor in maintenance requirements was strikingly shown during the year. This will be closed shortly.

3. *The metabolic requirements of dry cows* (Adams, VII) which alternately gain and lose weight between wide limits have been further studied. Individuality plays an important part in this trial, hence it is desirable that a considerable number of records be secured in order to minimize the effect of the personal equation.

4. *The nutritive values of milks of varying composition for infant feeding* (Adams, IV) a trial which has already borne fruit in the form of two publications—Nos. 195 and 201—has been vigorously

pursued during the year, using young pigs as laboratory animals and will be continued for some time to come.

5. *Trials of freezing cottage and other soft curd cheeses* (Hatch XVI) have demonstrated the possibility of carrying such cheeses in cold storage for considerable periods of time.

6. *Trials of the manufacture of Romano and Riccotta cheeses* (Hatch XVI) indicate that such cheeses may be successfully made in this country. A continued study of methods seems warranted.

7. *Equal quantities of bran and home grown and home ground alfalfa meal* were compared during alternate periods in the ration of the University milking dairy herd. In each case the alfalfa meal seemed at least equal in feeding value to wheat bran.

ADVANCED REGISTRY

During the past year supervisors have been furnished to 52 Vermont breeders who have had cows tested for advanced registry records.

The following statements set forth the work done.

Ayrshire—Seven breeders have had 101 cows on semi-official yearly tests, with a total of 421 tests for 842 days.

Guernsey—Six breeders have had 31 cows on semi-official tests, with a total of 137 tests for 274 days.

Holstein-Friesian—Twenty-two breeders have had 80 cows tested for 610 days.

Jersey—Seventeen breeders have had 217 cows on test for a total of 1,144 tests for 2,288 days.

Shorthorn—One breeder has had 8 cows on test for a total of 39 tests for 78 days.

Total of 53 breeders, 437 cows, 1,821 tests, 4,092 days.

The location of advanced registry work by counties is as follows: Windsor 10 breeders, Rutland 8, Windham 7, Franklin 7, Washington 7, Caledonia 3, Chittenden 3, Orleans 2, Lamoille 2, Orange 1, Addison 1, and Bennington 1.

The number of breeders availing themselves of this service, as well as the number of cows tested, has decreased as compared with last year, owing to the high cost of feed and shortage of farm help.

RECEIPTS

Cash on hand July 1, 1917	$ 333 04
Official test fees	3,364 94
	$3,697 98

DISBURSEMENTS

Salaries	$ 461 69
Labor	2,492 29
Postage, stationery, telephone and telegraph	109 88
Freight and express	8 37
Chemicals and laboratory supplies	36 97
Sundry supplies	4 95
Furniture and fixtures	26 00
Travel (supervisors)	255 37
Travel (official)	4 00
	$3,399 52

ASSETS

Receipts (as stated above)	$3,697 98
Due from breeders	320 61
	$4,018 59

LIABILITIES

Disbursements (as stated above)	$3,399 52
Due supervisors	280 20
	$3,679 72
Cash on hand June 30, 1918	$ 298 46
Excess amount due from breeders over amount due supervisors	40 41
	$ 338 87

BOTANY

The present status of the botanical projects is as follows:

1. *Tolerance of forest trees* (Adams, XI). This work has been continued along the lines discussed in previous reports. Forest, nursery and pot cultures are under observation in the attempt to determine the relative value of the various factors which make up the climate on the development and tolerance of forest seedlings. Field and nursery work seem to indicate the importance of conducting pot culture experiments with accurate control of conditions if this line of forest investigation is to be placed on a scientific basis.

2. *Eccentric growth* (Hatch, IV). The study of eccentric growth and the quality of the wood in different parts of trees has been continued along experimental lines in the greenhouse with results which seems to show that trees respond very little, if at all, to the mechanical stimuli used but that the cause of so-called "red wood" is to be sought in relative amounts of nutrition on the different sides of the tree.

3. *Forest reproduction* (Hatch, VI). The work on this problem has consisted in making accurate records of the changes in the clearings made in the various state forests during the past year. Such changes were accurately recorded on maps and show both the qualitative and quantitative changes that have taken place in the vegetation of the

clearing. These sample plots are located in different types of forests at Plainfield, West Rutland, Proctorsville, Townshend and Burlington.

4. *The storage of starch* (Adams, VI). An anatomical study of material collected during past years has been begun.

5. *Plant breeding* (Adams, XIII). The study of sterility and its nature has been continued in the field and by the use of much fixed material. Special stress has been laid on the crossing of plants and germination of the resulting seedlings. Something over 200 of these seedlings has developed into vigorous plants and will give much valuable material for the solution of the problems in hand. Several additional areas have been visited for study in the field and many plants have been added to the experimental garden.

CHEMISTRY

The work for the past year is covered, in a general way by the analyses of commercial fertilizers; of commercial feeding stuffs; analytical work connected with feeding trials with dairy cows, including roughages, concentrates and milk; together with the usual miscellaneous analyses of agricultural materials.

1. *Feeding values of milks of different grades for infant feeding* (Adams, IV). This project was vigorously pushed until late spring when inability to get help—due to the draft—necessitated a temporary cessation. Nine litters of pigs have been fed, slaughtered and prepared for analysis; analytical work is in progress and the necessary calculations are in hand.

2. *Soil studies* (Hatch, V, 1). About 100 samples of soil have been examined for lime requirement and organic matter content and the results reported to the parties interested. Many samples of limestone and marl submitted have received attention.

3. *Quality and quantity studies with squash* (Hatch, V, 2; VIII). Partial analyses of 208 samples of squash have been made for the department of horticulture with a view of correlating dry matter and protein content to quality factors.

4. *The carbohydrate content of maple wood* (Adams, VI) has been studied as time permitted. Thirty-two samples of bark were analyzed. An examination of the fresh leaves as to their sugar and starch content has been started designed to determine daily and monthly changes in composition. Eighty-seven samples have been analyzed. This work will be continued the coming year.

A total of 3,014 samples has been analyzed.

Milk (station herd) (Adams, V)	204
Milk and cream (from private individuals) (Hatch, V, 3)	547
Commercial fertilizers (official)	139
Commercial feeding stuffs (official)	506
Roughages and concentrates (Adams, V)	475
Bark and leaves (Adams, VI)	119
Miscellaneous (Horticultural dept.) (Hatch, V, 2)	208
Carcass (Pig) analyses (Adams, IV)	462
Miscellaneous (from private individuals) (Hatch, V, 1, 3)	354
	3,014

INSPECTION WORK

1. *Commercial fertilizers.* One hundred thirty-nine brands, the output of 17 companies, were analyzed. At the present writing the results are on file in manuscript form.

2. *Commercial feeding stuffs.* Five hundred and six samples of feeding stuffs offered for sale in the State were collected during March, April and May and have been analyzed for their protein content only. At the present writing the manuscript results are on file.

3. *Creamery glassware and operators.* The usual number of cream and milk bottles have been examined as to their accuracy. Incorrectly graduated glassware is still occasionally found. Thirty-eight operators of the Babcock test were licensed during the year.

4. *Agricultural seed.* Samples were drawn as usual, but the analyses are necessarily delayed, the analyst having resigned to enter an Officers' Training Camp. At the present writing it is problematical when the work will be done and the results published. Good seed analysts are not easy to find at the minimum wage Vermont can pay.

FORESTRY

The two lines of work outlined have been continued.

1. *The permanent sample plot work* (Hatch, VI) has been conducted in cooperation with the department of botany and in the main involves for the present the maintenance of the botanical records by visitation and minute inspection on the five sample plots in Plainfield, West Rutland, Proctorsville, Townshend and Burlington. The war situation has made it difficult or impossible to maintain the visitation during the present year, but it is hoped that the project can be kept afloat until happier days dawn.

2. *The hardwood factor study* (Hatch, VII) has been pushed to completion, a manuscript prepared and is being printed.

HORTICULTURE

The departmental work has been on the following projects:

1. *Sterility of strawberries* (Adams, XIV). The breeding work has been continued, further generations secured, and much data is accumulating on the behavior of progeny of perfect and imperfect varieties. The hybridizing operations have been completed, and the self-pollination work and the "fixing" and stabilizing processes are being effected.

2. *Cion selection* (Hatch, X). The testing of the comparative value of cions taken from high and low yielding parent trees is a slow process. It takes time for the cions to grow, and several years must elapse before fruiting propensities can be fully ascertained. More data is secured on bloom, yield, wood growth, etc., as more cions come to the fruiting age and size. A few cions have borne several times.

3. *Quality and quantity in Hubbard squash* (Hatch, VIII). The quantitative studies have been completed, and much of the data has been tabulated. The study of quality in parent and offspring has been continued on a larger scale than hitherto. Up to date over 400 specimen squashes have been cooked and tested as to palatability, moisture, texture, etc. Through the cooperation of the chemical department certain ingredients are being determined with reference to good and poor quality squashes. Breeding experiments are being continued to determine the control of quality. Seven different strains of about one acre in extent have been planted for the 1918 crop.

4. *Influence of continued self-pollination on the quality of fruit and vitality of offspring* (Adams, XVI). The Hubbard squash and the strawberry are being used, as certain advanced forms of both species were in hand from other experimental material. Selections and plantings have been made, and the current year crops will place the squashes in the fourth and the strawberries in the third generation following self-pollination.

5. *Strawberry runner selection* (Hatch, IX). Nothing has been accomplished in this experiment during the past year. The plants in the test have been nurtured, and a crop will be harvested in 1918.

6. *Cherry graftage* (Hatch, XI). The work of budding and grafting the seedlings has been somewhat interrupted by the severe winter of 1917-18, and a new start has been made with some species.

It is hoped to determine ultimately the interrelation of stock and cion for several species of cherry.

7. *Apple varieties.* Although not hitherto listed this experiment was instituted many years ago. The apparent aim was to study the most common varieties of apples with respect to blossom periods, bud formation, yields, resistance of disease, period for use, and storage endurance. About two acres were planted in 1904 by the former horticulturist. During the past year particular attention has been given to the preservation of apples under definite humidity and temperature conditions such as are probably available on most Vermont farms.

PLANT PATHOLOGY

The plant pathology projects and the progress made on them during the year may be set forth as follows:

1. *Potato scab* (Adams, X). Observations were continued on resistant and susceptible varieties. The effect of fertilizers and chemicals on the thickness of the skin of three varieties was studied again as in the preceding year and it was decided that no marked change is induced by their use. The thickness of the skin seems to be fairly constant for a single variety.

2. *Effect of bordeaux on sprayed plants* (Adams, VIII). The potato disease known as "tip-burn" is the cause of the greater part of the loss in unsprayed plants. Shading largely prevents this injury as does spraying with copper. The beginning and advance of the disease was studied in the field during the summer and a series of drawings of leave correlated with the sunshine and temperature. Observations have been continued on the effect on different varieties. Chemical studies have been made of leaves.

3. *The fusarium wilt of peas and asters* (Adams, XII). No experimental work has been undertaken on this project during the year.

4. *Club-root of cabbages and allied plants* (Hatch, XIII). No correlation was found between the Wisconsin strain of cabbage resistent to wilt and strains resistent to club-root. No further work has been undertaken on this project.

5. *Digestion of fungus spores by animals* (Hatch, XIV). One year's trial seemed to show that the spores of oat, barley and corn smuts were killed when passed through the digestive tract.

VETERINARY SCIENCE

1. *The treatment of infectious abortion* (Hatch, XV). Difficulties encountered in securing animals suitable for experimental treatment have interfered with the progress of this project. New outbreaks of the disease in the territory worked have been less frequent than usual and small numbers of reacting pregnant cows have been found in most of the herds tested. Most people object strenuously to leaving a portion of their herd untreated to serve as control, although they do not seem to object to any kind of treatment if applied to the entire herd or to all animals reacting to the blood tests used.

2. *Control of blood complement* (Adams, XV). Complement determinations were made on the blood of 1,034 additional guinea pigs produced during the year. A preliminary report covering the breeding of over 4,000 guinea pigs has been prepared for publication in which the results of selective matings with reference to blood complement are briefly presented.

The production of animals whose blood might serve as suitable material for the determination of the true functions of complement has been anticipated throughout the breeding experiments involved in project No. 2 but the loss of a large number of the animals caused by disease and errors in feeding deferred the beginning of resistance experiments until the middle of the past year.

During the last few months a large number of these animals with blood of low complement titre has been employed, immunity experiments and some interesting results have been obtained.

In March, 1917, over 700 guinea pigs produced in the blood complement control project died within three weeks after substituting beet pulp for raw beets in their diet, which also contained a liberal supply of grain and chopped hay. The addition of skimmilk served to supply the deficiency. Fifty guinea pigs were fed hay, grain and beet pulp and a control of fifty others received a small amount of skimmilk in addition to their hay, grain and beet pulp. The animals having no milk soon began to lose weight and all died within 30 days, while all of the control animals remained healthy for several months.

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JUNE, 1919 BULLETIN 213

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COLD STORAGE OF COTTAGE AND OTHER SOFT CURD CHEESES

by H. B. ELLENBERGER

BURLINGTON
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1919

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BULLETIN 213: COLD STORAGE OF COTTAGE AND OTHER SOFT CURD CHEESES

By H. B. Ellenberger

SUMMARY

1. The studies reported upon in this article must not be considered as conclusive although the trials which have been made demonstrate without doubt that cottage cheese may be held frozen in cold storage for several months and come out in condition satisfactory for food and market purposes. There seems to be no good reason why much larger quantities should not be stored during the flush season to be consumed later on during the period of low production.

2. The cheese held in storage from four to five months from August to the end of December was better in quality than was the fresh cheese then on sale in Burlington.

3. The cheese which was held in storage for seven and one-half months, from early August until April, developed a decidedly disagreeable flavor though not sufficiently so as to make it unsaleable. Whether this resulted from the protracted storage period or from some other cause was not determined.

4. On the whole the texture of the cheese was but slightly changed by storage except that the pot cheese was rendered a little more granular.

5. Tests for acid did not show any appreciable increase during the storage period but the most common criticism of flavor was that a tart high acid flavor had developed.

6. The cottage cheese made by the bakers' process held its flavor a little better than that made by the pot method.

7. The cheese made from pasteurized milk withstood storage slightly better than that made from raw milk.

8. The cheese which was drained fairly dry scored a little higher after storage than did the cheese which was packed rather wet. This wet cheese leaked somewhat upon removal from storage.

9. The addition of sweet skimmilk to dry cheese after removal from storage had little effect on the flavor although in some cases it seemed to bring out the tart acid flavor more clearly.

10. The practice of washing pot cheese curds during draining tends to eliminate taints and reduce acid in the fresh cheese, but the washed cheese deteriorates more during storage.

11. Pot cheese curds which were chilled before being packed retained their flavor a little better than the curds which were packed while still warm.

12. There was apparently no difference in the keeping quality of salted and unsalted curds.

13. The loss in weight of the storage cheese ranged from less than one percent to over eight percent, the average on 15 tubs being 2.62 percent.

14. It seems advisable to paraffin and line, or at least to line, wooden packages in which the cheese may be stored. No lining is necessary in well tinned cans.

15. The keeping quality of the cheese after removal from storage was nearly though not quite so good as that of fresh cheese.

16. Neufchatel curd keeps very well in storage but cream cheese tends to develop a metallic and old fat or rancid flavor. Dry neufchatel curds kept better than those which contained more moisture.

Introduction

The American public is coming to realize more fully than heretofore the value of cheese in the diet and its consumption is increasing accordingly. This is especially true of cottage cheese, the demand for which is growing rapidly as a result of the high price of other protein foods and a clearer understanding as to its food value.

A PLENTIFUL SUPPLY IN SUMMER

During the spring and early summer months there is always a plentiful supply of skimmilk in creameries and on farms from which cottage cheese may be made. Market demands are readily supplied at such times. From late summer to early winter, however, the reverse is true; the demand continues or increases while the supply of skimmilk diminishes. Many dealers cannot secure enough cottage cheese during this season to meet the requirements of their trade. The problem in the spring is to secure a profitable market for skimmilk and cottage cheese while in the fall it is difficult to secure enough of the cheese to meet the market demand. On this account cottage cheese is comparatively cheap in the spring and summer while in the fall and winter the price is necessarily increased because of the lessened supply and greater cost of production. And what is true of cottage is also more or less true as to the other soft curd cheeses, such as neufchatel and cream.

SOFT CHEESE A PERISHABLE PRODUCT

Soft cheese, particularly cottage, is very perishable because of its high moisture content. If kept at ordinary temperatures it will only remain fit for food for a few days. If held at near freezing temperature, it may be kept in fair condition for from two to three weeks, but not for a long enough time to exert much balancing influence between the spring and fall and winter supply.

STORAGE PROBLEM IMPORTANT

The problem of making this cheese in the spring and summer and successfully storing it for fall and winter consumption naturally presents itself as of considerable importance. Not long ago a like situation applied in a great measure to butter and eggs, though these

products are less perishable than cottage cheese. Cold storage has revolutionized these and many other lines of business by making possible the holding of stock produced in the flush season for use during the months of low production. It seems probable, since it is absolutely impossible profitably to market for immediate consumption all the cottage cheese which can be produced during the spring and early summer, that the ultimate solution of this perplexing problem is to put cottage cheese in storage during these months to be taken out for consumption in the fall and winter when there is little surplus skimmilk from which to manufacture such cheese. If this can be done it will tend to stabilize the market since the demand will be increased during the storage season which will insure a market to the producer and the consumer will then be able to secure cottage cheese at, perhaps, a more reasonable and surely at a more nearly uniform price throughout the year.

During the fall of 1917 the writer inaugurated several practical tests to determine whether such cheese could be held frozen in cold storage for several months and be taken out in condition satisfactory for food and market purposes. These preliminary trials were so successful that the work was continued on a much larger scale during the fall and winter of 1918.

1917 TRIALS

Several lots of skim- and whole milk were made into cottage, neufchatel and cream cheeses, which, after being sampled and analyzed, were placed in cold storage where they were kept frozen. The room temperature where they were held was maintained at 14° to 16° F. Such temperature, of course, necessitated artificially cooled storage. Some of the cheese was allowed to develop a high acid content during the making process while some was made very moist and some quite dry. Cottage cheese was made by both the bakers' and the pot methods. These different lots were held in storage for a maximum of four and one-half months.

Table 1 shows the composition of the cheese which was placed in storage. Quite wide variations will be noted in different samples, due mainly to differences in moisture content. These variations were desired and intended in order to determine the effect of different moisture contents on the keeping qualities of the cheese.

TABLE I—COMPOSITION OF CHEESE STORED IN 1917

Kind of cheese	Water %	Fat %	Protein %	Salt %	Total ash %	Salt in ash %	Ash salt-free %	Lactic acid, milk sugar, etc. %
Cottage (Bakers')	79.90	0.39	12.67	2.30	2.10	1.50	0.60	4.14
" "	76.10	0.51	17.23	1.40	1.10	0.90	0.20	4.56
" "	76.90	1.90	15.76	0.80	1.65	0.80	0.85	3.79
" "	73.18	0.57	18.57	2.50	2.76	2.00	0.76	4.42
" "	71.95	0.45	20.36	1.90	1.80	0.80	1.00	4.34
" (Pot)	71.40	1.35	21.05	1.30	1.58	0.50	1.08	3.82
" "	75.15	0.99	16.78	2.00	1.90	1.20	0.70	4.38
" "	73.10	1.20	19.26	1.50	1.40	0.60	0.80	4.14
Neufchatel	60.35	21.00	14.00	1.70	1.45	1.00	0.45	2.50
"	52.70	27.00	15.76	2.00	1.50	0.90	0.60	1.94
"	60.10	20.25	14.50	1.80	1.65	1.10	0.55	2.80
"	51.65	27.00	17.12	2.00	2.20	1.40	0.80	1.43
"	65.05	17.80	13.12	1.40	1.20	0.70	0.50	2.13
"	56.70	23.25	15.76	2.20	2.05	1.50	0.55	1.54
Cream	57.65	28.50	11.00	0.90	1.00	0.40	0.60	1.35
"	45.10	37.50	13.62	1.80	1.75	1.20	0.55	1.43

The flavor of most of these samples of stored cheese when thawed was but slightly altered, the only appreciable difference in most cases being that the flavor seemed to have become a little sharper or more tartly acid. The flavor of those samples which contained a high percentage of moisture seemed to be somewhat poorer than that of the dryer lots made from the same curds.

Cottage cheese made by the pot method retained its flavor as well as or a little better than that made by the bakers' method. Practically all samples of neufchatel were nearly as good when removed from storage as when they were stored. The cream cheese developed some metallic flavor.

Some of this storage cheese, after being thawed out, was repacked into small retail packages. Persons who know nothing of its history pronounced it "fine." Several, on being told—after it was eaten—that it was storage cheese stated that they could not distinguish it from fresh goods. Some of these persons were expert in judging dairy products.

The texture of several samples was somewhat changed by freezing. Cottage cheese made by the pot method became a little more grainy and crumbly as did also very dry neufchatel. When very moist cottage cheese made by the bakers' process was stored it became a little pasty and leaked somewhat when thawed, but medium or dry cheese from the same curd showed practically no change.

1918 TRIALS

During August, 1918, nearly 100 different lots of cheese were made, which, after having been scored and tested for moisture and acid, were placed in cold storage and held till December 24 when all but seven tubs were withdrawn. The seven were held until March 28, 1919.

The milk was purchased from a country creamery and was of fairly good quality. The cheese was packed and stored in 20-pound spruce butter tubs which had previously been soaked, paraffined and lined with parchment paper, being placed in cold storage within from 24 to 72 hours. The temperature of the storage room ranged from 14° to 18° F. and from two to three days were required for the cheese to freeze through to the center of the tub.

Each lot of cheese was examined by the writer when placed in storage. Flavor and texture were rated respectively on the basis of 50 and of 35 for perfection. The cheese removed from storage on December 24, four to five months after being made, was examined and scored by several experienced judges, Professors H. E. Ross and W. W. Fisk of Cornell University, and Messrs. M. R. Tolstrup, Field Agent in Marketing, and V. R. Jones, Dairy Manufacturing Specialist of the office of the State Commissioner of Agriculture. The courtesy of these gentlemen is greatly appreciated. The samples which were held until March 28, 1919, were judged by O. M. Camburn, Dairy Specialist of the Vermont Extension Service, the writer and several other persons more or less familiar with the quality desired in cottage cheese.

The cheese referred to as "bakers' " was made from skimmilk by tempering to 72° to 75° F. and then adding about one percent of starter and rennet extract at the rate of one-half ounce per 1,000 pounds of milk. The lot was then left unmolested until a firm coagulation was obtained and the whey tested from 0.45 to 0.50 percent acid. It was then dipped into cotton bags and drained without the application heat. The "pot" cheese was made by adding starter to the skimmilk at the rate of from 1 to 10 percent, the milk being tempered to 70° to 85° F. This was allowed to stand until a firm curd formed when it was cut and heated to about 100°F. until it became firm enough to dip to a curd sink to drain.

KEEPING QUALITY OF BAKERS' AND POT CHEESE

A comparison of 17 lots each of bakers' and pot cheese is shown in table II. The August scores were made by the writer while the scores

made on December 27-28 represent the average judgment of Messrs. Ross, Fisk, Tolstrup, Jones and the writer. The bakers' cheese depreciated 1.7 points on flavor and 0.1 point on texture and the pot cheese 2.7 points on flavor and 0.5 point on texture. Apparently the pot cheese did not hold up quite as well under storage as did the bakers'.

TABLE II—KEEPING QUALITY OF BAKERS' AND POT CHEESE COMPARED

	Score when stored in August				Score after storage December 27			
	Flavor		Texture		Flavor		Texture	
	Bakers'	Pot	Bakers'	Pot	Bakers'	Pot	Bakers'	Pot
	48.5	49.5	34.	33.	45.6	46.1	33.2	34.1
	48.5	49.	33.5	32.	44.5	46.1	33.	33.1
	48.	48.	33.	34.	45.7	44.5	33.4	33.
	48.	48.	33.5	33.5	46.1	44.7	33.2	33.1
	47.	49.	32.5	34.	44.7	46.5	33.8	33.7
	48.	49.	34.	33.5	44.9	46.	33.4	31.5
	49.	44.	35.	33.	48.	44.4	34.	33.7
	48.	48.	33.5	34.	45.5	45.	32.9	33.
	48.5	48.	34.	34.	45.	44.7	32.7	33.1
	45.5	49.	32.5	34.5	44.7	46.	33.6	33.9
	46.	49.5	33.	34.	45.6	45.5	33.3	33.
	46.5	48.	33.	34.5	45.6	46.	33.4	33.9
	46.5	47.5	34.5	34.5	47.1	46.6	34.	33.5
	47.	47.	34.	34.	45.7	46.7	32.8	33.2
	47.	49.	34.5	34.	46.5	45.2	34.7	33.
	48.	48.	34.	34.5	46.	44.1	34.5	33.7
	48.5	48.	34.5	33.5	46.4	44.9	34.6	33.4
Totals	805.5	818.5	573.	574.5	777.6	773.	570.5	565.9
Averages	47.5	48.2	33.7	33.8	45.8	45.5	33.6	33.3
Losses					1.7	2.7	0.1	0.5

KEEPING QUALITY OF COTTAGE CHEESE MADE FROM RAW AND PASTEURIZED MILKS

The cheese made from milk which had been pasteurized kept slightly better in storage than did that made from raw milk, as is shown in tables III and IV.

TABLE III—KEEPING QUALITY OF CHEESE MADE FROM RAW AND PASTEURIZED MILKS (BAKERS' METHOD)

	Score when stored in August				Score after storage December 27			
	Flavor		Texture		Flavor		Texture	
	Pasteurized	Raw	Pasteurized	Raw	Pasteurized	Raw	Pasteurized	Raw
	48.	48.	32.	33.5	45.6	45.5	34.2	32.9
	48.	48.	32.	33.5	46.7	45.9	34.4	33.6
	49.	48.5	35.	34.	47.6	45.	33.9	32.7
	46.5	45.5	33.	32.5	45.6	44.7	33.4	33.6
	46.5	45.	34.	33.	46.6	45.	33.9	33.8
	46.5	45.5	34.5	34.	47.1	46.	34.	33.9
	46.5	46.	34.	33.	46.5	45.6	34.	33.3
	49.	47.	35.	34.5	48.	46.5	34.	34.9
Totals	380.	373.5	269.5	268.	373.7	364.2	271.8	268.7
Averages	47.5	46.7	33.7	33.5	46.7	45.5	34.	33.8
Losses or gains					—0.8	—1.2	+0.3	+0.3

TABLE IV—KEEPING QUALITY OF CHEESE MADE FROM RAW AND PASTEURIZED MILKS (POT METHOD)

	Score when stored in August				Score after storage December 27			
	Flavor		Texture		Flavor		Texture	
	Pasteurized	Raw	Pasteurized	Raw	Pasteurized	Raw	Pasteurized	Raw
	49.	49.5	33.5	33.	46.	46.1	32.3	34.1
	49.	49.	35.	32.	46.2	46.1	33.9	33.1
	45.	48.	32.	34.	44.6	45.	33.4	33.
	47.	48.	34.	34.	45.5	44.7	33.7	33.1
	49.	49.	34.	34.	46.7	45.2	34.	33.
	48.	44.	34.	33.5	44.4	44.9	33.5	33.7
	46.5	45.5	33.5	33.	44.2	45.1	33.1	31.6
	47.5	48.5	33.5	32.5	44.2	44.9	31.2	32.9
	48.	49.	34.5	34.5	46.	46.	33.9	33.9
	47.5	49.5	34.5	34.	46.6	45.9	33.5	33.2
	47.	49.	34.	34.	46.7	45.2	33.2	33.4
	48.	46.	34.	33.5	44.5	45.4	33.	33.2
	48.	48.	33.5	33.	44.7	44.7	33.1	33.9
Totals	619.5	623.	440.	435.	590.3	589.2	431.8	432.1
Averages	47.7	47.9	33.8	33.5	45.4	45.3	33.2	33.2
Losses					2.3	2.6	0.6	0.3

EFFECT OF MOISTURE CONTENT OF KEEPING QUALITY

A comparison of the keeping quality of moist cottage cheese and of rather dry cottage cheese is shown in tables v to viii. Only slight differences were observed. The moist cheese, however, lost considerable free moisture when thawed after removal from storage.

TABLE V—KEEPING QUALITY OF WET AND DRY BAKERS' CHEESE MADE FROM RAW MILK

	Moisture content		Score when stored in August. Flavor		Texture		Score after storage Dec. 27 Flavor		Texture	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
	78.17	75.41	48.	48.5	34.	34.5	46.	46.4	34.5	34.6
	78.18	75.42	48.	48.5	34.	34.5	44.5	47.	33.7	34.7
	76.52	72.00	48.	48.5	33.5	34.	45.5	45.	32.9	32.7
	76.53	72.00	48.	48.5	33.5	34.	45.9	45.6	33.6	32.4
	79.67	75.60	45.5	45.5	32.5	34.	44.7	46.	33.6	33.9
	78.37	71.90	48.5	48.5	34.	33.5	45.6	44.5	33.2	33.
Totals	467.44	442.33	286.	288.	201.5	204.5	272.2	274.5	201.2	201.3
Averages	77.91	73.72	47.7	48.	33.6	34.1	45.4	45.7	33.6	33.5
Losses							2.3	2.3		0.6

TABLE VI—KEEPING QUALITY OF WET AND DRY BAKERS' CHEESE MADE FROM PASTEURIZED MILK

	Moisture content		Score when stored in August. Flavor		Texture		Score after storage Dec 27 Flavor		Texture	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
	77.30	73.70	48.	49.	31.	35.	45.6	47.6	34.2	33.9
	79.05	76.35	46.5	46.5	33.	34.5	45.6	47.1	33.4	34.
	76.55	75.80	48.	48.	33.	33.5	45.7	46.1	33.4	33.2
	78.93	70.90	47.	48.	32.5	34.	44.7	44.9	33.8	33.4
	76.30	71.22	47.	48.	34.	34.5	47.	45.5	33.	32.5
Totals	388.13	367.97	236.5	239.5	163.5	171.5	228.6	231.2	167.8	167.
Averages	77.63	73.59	47.3	47.9	32.7	34.3	45.7	46.2	33.6	33.4
Losses or gains							—1.6	—1.7	+0.9	—0.9

TABLE VII—KEEPING QUALITY OF WET AND DRY POT CHEESE MADE FROM RAW MILK

	Moisture content		Score when stored in August. Flavor		Texture		Score after storage Dec. 27 Flavor		Texture	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
	77.35	69.87	49.5	49.	33.	32.	46.1	46.3	34.1	33.1
	75.47	70.72	48.	48.	34.	34.	45.	44.7	33.	33.1
	75.48	70.73	48.	48.	34.	34.	43.5	44.5	32.6	33.2
	75.90	71.05	48.	48.	34.5	33.5	44.1	44.9	33.7	33.4
	73.95	64.90	48.5	48.5	34.5	33.	44.	44.7	33.6	32.1
	76.02	67.86	44.	45.5	33.5	33.	44.9	45.1	33.7	31.6
	76.15	69.20	49.	49.5	34.5	34.	46.	45.9	33.9	33.2
	73.10	70.15	46.	47.5	33.5	33.5	45.4	45.6	33.2	33.
Totals	603.42	554.48	381.	384.	271.5	267.	359.	361.7	267.8	262.7
Averages	75.43	69.31	47.6	48.	33.	33.9	44.9	45.2	33.5	32.8
Losses							2.7	2.8	0.4	0.6

TABLE VIII—KEEPING QUALITY OF WET AND DRY POT CHEESE MADE FROM PASTEURIZED MILK

	Moisture content		Score when stored in August. Flavor		Texture		Score after storage Dec. 27 Flavor		Texture	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
	74.77	74.37	44.	45.	31.	32.	46.9	46.1	34.2	34.
	75.00	72.15	45.	45.5	32.	33.	44.6	45.1	33.4	33.4
	75.85	71.05	48.	47.5	34.	33.5	44.4	44.2	33.5	33.2
	77.40	72.20	48.	47.5	34.5	34.5	46.	46.6	33.9	33.5
	70.75	69.27	48.	48.	34.	33.5	44.5	44.7	33.	33.1
	74.42	68.15	49.	49.	34.	33.5	46.5	46.	33.7	31.5
Totals	448.19	427.19	282.	282.5	199.5	200.	272.9	272.7	201.7	198.7
Averages	74.70	71.20	47.	47.1	33.2	33.3	45.5	45.4	33.6	33.1
Loss or gains							—1.5	—1.7	+0.4	—0.2

EFFECT OF ACID DEVELOPMENT ON KEEPING QUALITY

The results of trials to determine whether differences in keeping qualities may be observed as between cheeses made with small amounts and with large amounts of starter are shown in table IX and X. Higher acid was developed as a result of the use of larger quantities of starter or at least it was developed faster so that the curd had such acid development for a longer period before dipping or cooking. In each case the cheese made with the smaller amount of starter scored a little higher when fresh but deteriorated a little more during storage so that the two classes were practically equal in quality when taken out of storage.

TABLE IX—KEEPING QUALITY OF BAKERS' CHEESE MADE WITH LOW AND HIGH PERCENTAGES OF STARTER

	Percent starter used		Acid in whey at dipping		Score when stored in Aug. Flavor		Texture		Score after storage Dec. 27 Flavor		Texture	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
	1	10	0.54	0.56	48.5	47.	34.5	34.5	46.4	46.5	34.6	34.8
	1	10	0.54	0.56	48.5	47.	34.5	34.5	47.	44.6	34.7	34.3
	1	8	0.46	0.52	49.	49.	35.	35.	47.6	48.	33.9	34.
	1	13	0.58	0.59	48.	47.	34.5	34.	45.5	45.7	32.5	32.8
Totals	4	41	2.12	2.33	194.	190.	138.5	138.	186.5	184.8	135.7	135.9
Averages	1	10	0.53	0.58	48.5	47.5	34.6	34.5	46.6	46.2	33.9	34.0
Losses									1.9	1.3	0.7	0.5

TABLE X—KEEPING QUALITY OF POT CHEESE MADE WITH LOW AND HIGH PERCENTAGES OF STARTER

	Percent starter used		Acid in coagulated milk before cooking		Score when stored in Aug.				Score after storage Dec. 27			
					Flavor		Texture		Flavor		Texture	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
	1	6	0.90	0.90	48.	49.	34.	34.	44.7	45.2	33.1	33.
	1	6	0.90	0.90	48.	49.	34.	34.	45.	45.5	32.5	32.5
	1	10	0.75	0.86	48.5	48.5	33.	32.5	44.7	44.9	32.1	32.9
	1	5	0.70	0.76	49.5	49.	34.	34.	45.9	45.2	32.2	33.4
	0	10	0.91	0.91	48.	47.5	33.	33.5	44.7	44.7	32.9	33.1
	1	10	0.82	0.95	45.5	44.	33.	33.	45.1	44.4	33.4	33.7
	0.5	10	0.45	0.97	47.	45.	34.	34.	45.5	44.1	33.7	33.2
	1	6	0.71	0.75	47.5	47.	34.5	34.	44.6	46.7	33.5	33.2
Totals	6.5	63	6.14	7.	382.	379.	269.5	269.	360.2	360.7	264.4	265.
Averages	0.8	7.9	0.77	0.88	47.7	47.4	33.7	33.6	45.	45.1	33.	33.1
Losses					2.7	2.3	0.7	0.5				

EFFECT OF SALT ON KEEPING QUALITY

Nine lots of cheese were divided after draining and one part was salted while the other part was stored without the addition of salt. This latter was salted after removal from storage and before the cheese was judged. Table XI indicated that there was practically no difference in the keeping quality of the salted and the unsalted cheese.

TABLE XI—KEEPING QUALITY OF SALTED AND UNSALTED BAKERS' AND POT CHEESE

	Score when stored in August.				Score after storage Dec. 27			
	Flavor		Texture		Flavor		Texture	
	Salted	Unsalted	Salted	Unsalted	Salted	Unsalted	Salted	Unsalted
	48.	48.	34.	34.	46.	44.5	34.5	33.7
	48.5	48.5	34.5	34.5	46.4	47.	34.6	34.7
	47.	47.	34.5	34.5	46.5	44.6	34.7	34.3
	48.	48.	33.5	33.5	45.5	45.9	32.9	33.6
	48.5	48.5	34.	34.	45.	45.6	32.7	32.4
	48.	48.	31.	31.	45.6	46.7	34.2	34.4
	48.	48.	34.	34.	45.	43.5	33.	32.6
	48.	48.	34.	34.	44.7	45.	33.1	32.5
	49.	49.	34.	34.	45.2	45.5	33.	32.5
Totals	433.	433.	303.5	303.5	409.9	408.3	302.7	300.7
Averages	48.1	48.1	33.7	33.7	45.5	45.4	33.6	33.4
Losses					2.6	2.7	0.1	0.3

EFFECT OF WASHING WITH WATER DURING DRAINING ON THE KEEPING QUALITY OF POT CHEESE

The practice of washing pot cheese curd with water during the draining process seems to tend slightly to reduce the keeping quality of the cheese as shown in table XII.

TABLE XII—KEEPING QUALITY OF WASHED AND UNWASHED POT CHEESE COMPARED

	Percent acid in cheese		Score when stored in August				Score after storage Dec. 27			
			Flavor		Texture		Flavor		Texture	
	Not Washed	washed	Washed	Not washed	Washed	Not washed	Washed	Not washed	Washed	Not washed
	0.36	0.67	49.	48.	32.	34.	46.1	45.	33.1	33.
	0.36	0.57	49.5	48.	33.	34.	46.1	44.7	34.1	33.1
	0.45	....	48.	47.	34.	34.	44.4	45.5	33.5	33.7
	0.52	0.76	46.5	45.5	33.5	33.	44.2	45.1	33.1	31.6
	0.45	0.58	47.5	45.	33.5	32.	44.2	46.1	33.2	34.
Totals	2.14	2.58	240.5	233.5	166.	167.	225.	226.4	167.	165.4
Averages	0.43	0.64	48.1	46.7	33.2	33.4	45.	45.3	33.4	33.1
Losses or gains							—3.1	—1.4	+0.2	—0.3

EFFECT OF COOLING POT CHEESE BEFORE TUBBING ON THE KEEPING QUALITY

Since the cheese did not reach the cold storage house until it was from one to three days old it was thought that perhaps if it was placed in the tubs while still warm it would deteriorate more than if it were chilled near ice before tubbing. Table XIII indicates that the cheese which was chilled before tubbing kept a little better than that which was tubbed while still warm.

TABLE XIII—KEEPING QUALITY OF POT CHEESE TUBBED WARM AND COOLED BEFORE TUBBING

	Score when stored in August.				Score after storage Dec. 27			
	Flavor		Texture		Flavor		Texture	
	Cooled	Not cooled	Cooled	Not cooled	Cooled	Not cooled	Cooled	Not cooled
	49.5	49.	34.	34.	45.9	45.2	33.2	33.
	49.	48.5	34.5	34.5	46.	44.	33.9	33.6
	49.	48.5	34.	33.	45.2	44.7	33.4	32.1
	49.	48.5	34.	32.5	46.5	44.9	33.7	32.9
	49.	48.	33.5	34.5	46.	44.1	31.5	33.7
	48.	48.	33.	33.5	44.7	44.9	32.9	33.4
	47.5	48.	33.5	34.	45.6	45.	33.	33.
	47.5	48.	33.5	34.	44.7	44.7	33.1	33.1
	47.	48.	34.	34.5	45.5	46.	33.7	33.9
	46.	47.5	34.	34.5	45.6	46.6	33.2	33.5
	46.	47.	33.5	34.	45.4	46.7	33.2	33.2
Totals	527.5	529.	371.5	373.	501.1	496.8	364.8	365.4
Averages	48.	48.1	33.8	33.9	45.5	45.2	33.2	33.2
Losses					2.5	2.9	0.6	0.7

EFFECT OF WORKING SKIMMILK INTO DRY COTTAGE CHEESE AFTER REMOVAL FROM STORAGE

Several tubs of rather dry cottage cheese were divided after removal from storage and to one part of each tub some skimmilk was added and worked in. The result of this attempt to improve the quality of the product is shown in table XIV, which indicates that it does not appreciably better either the flavor or the texture.

TABLE XIV—EFFECT OF ADDING SKIMMILK TO THE DRY COTTAGE CHEESE AFTER REMOVAL FROM STORAGE

Cheese without added skimmilk		Cheese with added skimmilk	
Flavor	Texture	Flavor	Texture
47.6	33.9	47.1	34.4
48.	34.	46.5	34.
44.5	33.	45.4	33.
45.6	33.3	46.1	33.3
44.9	33.4	47.2	34.5
45.5	32.5	46.2	32.7
45.7	32.5	46.5	32.8
46.1	33.1	46.4	34.1
46.1	34.1	46.1	33.7
44.7	33.1	44.5	33.2
44.9	33.4	45.4	33.4
44.	33.6	45.2	32.9
45.9	33.2	45.5	33.
44.7	32.9	43.1	32.2
44.7	33.1	45.	33.2
46.5	33.7	46.7	34.
46.	31.5	45.7	31.7
Totals 775.4	564.3	778.6	566.1
Averages 45.6	33.2	45.8	33.3

EFFECT OF KIND OF PACKAGE IN WHICH CHEESE WAS STORED

Only one comparison of storing the cheese in different packages was made. Lot 78 was divided into five portions. A was packed in 4-ounce retail packages which were boxed; B was packed, as were all the other lots, in a paraffined butter tub lined with parchment paper; C in a well tinned ice cream can; D in a rusty tin can without lining; and E in a spruce butter tub, unparaffined and without lining. The results are shown in table xv. It will be noted there was little difference in the quality of these different lots when removed from storage with the exception that lot E which was considerably the worse as a result of its contact with the unprotected wood.

TABLE XV—EFFECT OF KIND OF PACKAGE ON KEEPING QUALITY

Lot	Score when stored in August		Score after storage on Dec. 27			
	Flavor	Texture	Flavor	Loss	Texture	Loss
A	47.	34.	46.2	.8	33.3	.7
B	47.	34.	46.3	.7	33.	1.
C	47.	34.	46.2	.8	32.8	1.2
D	47.	34.	46.	1.	33.	1.0
E	47.	34.	44.7	2.3	31.8	2.2

LENGTH OF THE STORAGE PERIOD AND ITS EFFECT ON QUALITY

Very little information was obtained on this subject but at the time of removing the bulk of the cheese from storage in December seven tubs were opened, the contents divided and one part was replaced in the tub and held in storage till March 28. Table XVI shows the score of these lots as they were placed in storage, as they were when removed in December and again as they were when scored April 1. It will be noted that there was a decided deterioration in quality from December to April by which time the cheese had developed a distinctly poor flavor though it still was considered marketable. More definite information is needed as to the effect of the length of the storage period on the quality of the cheese. The temperature of the freezer room where cheeses are held may also have a marked influence. These were all held in the same room so no information was obtained on this latter point.

TABLE XVI—EFFECT OF LENGTH OF STORAGE PERIOD ON QUALITY OF CHEESE

	Score when stored in August		Score after storage till Dec. 27		Score after storage till April 1	
	Flavor	Texture	Flavor	Texture	Flavor	Texture
	49.	35.	47.6	33.9	41.9	32.
	49.	35.	48.	34.	32.3	33.
	48.5	34.	45.6	33.2	39.	32.
	49.5	33.	46.1	34.1	42.7	33.5
	49.	34.	45.2	33.0	40.7	32.
	48.	34.5	46.	33.9	41.3	33.5
	49.	34.	46.5	33.7	40.5	33.
Totals	342.	239.5	325.	235.8	288.4	229.
Averages	48.9	34.2	46.4	33.7	41.2	32.7

Losses August to December	2.5	0.5
Losses December to April	5.2	1.0
Losses August to April	7.7	1.5

ACID DEVELOPMENT DURING STORAGE

Many lots of cheese were tested for acid just before entering storage and again after they were removed and thawed. Table XVII illustrates the fact that the actual percentage of acid is increased but slightly if at all during storage. The acid content was determined by washing 10 grams of finely divided cheese for 30 minutes in water at 40° C, making up to 105 c.c., filtering, and titrating 25 c.c. portions of the filtrate.

TABLE XVII—ACID CONTENT OF CHEESE

Kind of cheese	Acidity when stored	Acidity when removed
	%	%
Bakers	0.54	0.55
"	0.54	0.54
"	0.58	0.59
"	0.41	0.43
"	0.61	0.58
"	0.63	0.63
"	0.59	0.58
"	0.68	0.65
Pot	0.47	0.47
"	0.44	0.40
"	0.36	0.49
"	0.67	0.63
"	0.56	0.63
"	0.45	0.42
"	0.32	0.43
"	0.52	0.56
Neufchatel	0.38	0.36
"	0.45	0.43
"	0.40	0.40
"	0.45	0.47
Cream	0.45	0.40
"	0.36	0.33
Totals	10.86	10.97
Averages	0.49	0.50

EFFECT OF STORAGE ON TEXTURE

The texture of the cheese was little changed by storage. A few of the wetter cheeses which leaked considerably when thawed improved in texture as a result while quite dry curds seemed to be a little more grainy after storage. This was especially noted in some of the pot cheese which was more granular after storage than when it was when fresh.

LOSS IN WEIGHT OF COTTAGE CHEESE DURING STORAGE

The net weight of several tubs of cottage cheese was recorded as they went into storage and again after they were removed and thawed. Every tub lost some weight. It will be noted that the dryer cheeses lost less in each case than did those which contained more moisture. The loss per tub varied from 0.88 to 8.46 percent, the average of the 15 tubs being 2.6 percent.

TABLE XVIII—LOSS IN WEIGHT OF COTTAGE CHEESE DURING STORAGE

Lot No.	Pct. moisture	Kind of cheese	Net weight of cheese when stored	Net weight of cheese after thawing out	Loss in weight	Percent loss in weight
1	78.2	Bakers' wet	23 pounds 13 ounces	22 pounds 13 ounces	16 ounces	4.2
1	75.4	" dry	23 " 5 "	22 " 13 "	8 "	2.14
4	76.5	" wet	15 " 8 "	15 " 1 "	7 "	2.82
4	72.	" dry	18 " 6 "	18 " 1 "	5 "	1.70
6	77.3	" wet	24 " .. "	23 " 1 "	15 "	3.91
6	74.7	" dry	18 " .. "	17 " 13 "	3 "	1.04
10	71.9	" dry	20 " 2 "	19 " 13 "	5 "	1.55
19	75.	Pot wet	23 " 7 "	22 " 13 "	10 "	2.67
19	72.1	" dry	22 " 9 "	22 " 1 "	8 "	2.22
22	71.	" wet	22 " 2 "	20 " 4 "	30 "	8.47
22	75.9	" dry	21 " .. "	20 " 9 "	7 "	2.08
27	76.	" wet	20 " 12 "	20 " 5 "	7 "	2.11
27	67.9	" dry	21 " 6 "	21 " 3 "	3 "	0.88
17	70.7	" dry	19 " 2 "	18 " 13 "	5 "	1.63
21	72.2	" dry	23 " 8 "	23 " 1 "	7 "	1.86
					Average	2.62

NEUFCHATEL AND CREAM CHEESE

A few lots of neufchatel and cream cheese were made at the same time and stored under the same conditions as were the cottage cheese. Table XIX shows a comparison of several lots of curd, part of which was tubbed while rather moist and part pressed till fairly dry.

TABLE XIX—KEEPING QUALITY OF MOIST AND DRY NEUFCHATEL AND CREAM CHEESE

	Moisture percent		Score when stored in August				Score after storage Dec. 27			
			Flavor		Texture		Flavor		Texture	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Neufchatel	67.25	61.70	47.	47.	33.5	33.	47.5	46.5	33.	32.1
	65.30	61.07	45.	45.	32.	32.	46.7	45.7	33.3	33.3
	69.54	61.90	46.5	46.	34.	34.5	44.8	47.	34.	34.3
	67.20	59.87	47.	46.5	34.	33.	45.8	46.2	34.	34.1
	67.92	59.52	47.	48.	33.	34.	45.1	44.	33.8	33.9
	66.27	58.77	46.	47.5	33.5	34.	44.5	44.7	34.3	33.5
Corn	49.59	49.50	48.5	49.	34.	35.	43.2	45.2	34.7	34.4
	56.25	49.56	48.	48.	33.	33.	45.7	46.	33.8	34.
Totals	509.32	460.89	375.	377.	267.	268.5	363.3	365.3	270.9	269.6
Averages	63.67	57.61	46.9	47.1	33.4	33.6	45.4	45.7	33.9	33.7
Losses or gains							—1.5	—1.4	+0.5	—0.1

Two slightly different methods of making up the neufchatel and cream cheese were followed. In those lots designated A in table XX, the milk for neufchatel was set at a temperature of 72° F. and that for cream at 75° F. while those lots designated B were set at 80° and 83° F. respectively. Rennet extract was added to the A lots at the rate of 3 c.c. per 100 lbs. and to the B lots at the rate of 1 c.c. per 100

lbs. One percent of starter was added in all cases. The B lots quite naturally develcped more acid in the whey by the time of dipping. The A lots while a little better in flavor when fresh deteriorated more while in storage than did the B lots.

TABLE XX—A COMPARISON OF THE KEEPING QUALITY OF CREAM AND NEUFCHATEL CHEESE MADE BY THE ABOVE OUTLINED METHODS

	Setting temperature		Percent acid in whey at dipping		Score when stored in Aug.				Score after storage Dec. 27			
					Flavor		Texture		Flavor		Texture	
	A	B	A	B	A	B	A	B	A	B	A	B
	72	80	0.56	0.65	47.	45.	33.5	32.	47.5	46.7	33.	33.3
	72	80	0.56	0.65	47.	45.	33.	32.	46.5	45.7	32.1	33.3
	72	80	0.57	0.60	46.5	47.	34.	34.	44.8	45.8	34.	34.
	72	80	0.57	0.60	46.	46.5	34.5	33.	47.	46.2	34.3	34.1
	72	80	0.41	0.55	47.	46.	33.	33.5	45.1	44.5	33.8	34.3
	72	80	0.41	0.55	48.	47.5	34.	34.	44.	44.7	33.9	33.5
	75	83	0.63	0.71	48.5	48.	34.	33.	43.2	45.7	34.7	33.8
	75	83	0.63	0.71	49.	48.	35.	33.	45.2	46.	34.4	34.
Totals			4.34	5.02	379.	373.	271.	264.5	363.3	365.3	270.2	270.3
Averages			0.54	0.63	47.4	46.6	33.9	33.1	45.4	45.7	33.8	33.8
Losses or gains									—2.0	—0.9—	0.1	+0.7

STORAGE CHEESE AND FRESH CHEESE COMPARED

At the time of scoring the cheese taken out of storage both in December and March, several samples of fresh cottage cheese offered for sale by local dealers were purchased and, after being repacked so that they could not be distinguished from the storage cheese by the nature of the package, they were distributed along with the samples of storage cheese. These served as a check on the work of the judges and gave a basis for comparing the commercial value of the storage cheese with that of the fresh cheese.

The average score of all the samples of storage cheese judged on December 27 and 28 was 45.6 points on flavor and 33.1 points on texture, while the six samples of fresh cheese which were judged at the same time scored an average of 44 points on flavor and 33.8 points on texture. The lowest score on this fresh cheese was 42 and the highest 46.3, while the low score on storage cheese was 44 and the high score 48.

Of the seven samples of storage cheese judged April 1, 39 was the lowest score and 42.7 the highest, the average being 41.2 while of three samples of fresh cheese judged at the same time with the storage cheese the low score was 41.6, the high score 45.7 and the average score 43.5.

It is, therefore, evident that the judges ranked the storage cheese scored in December as having a higher commercial value than the

fresh cheese which was being sold on the Burlington market at that time. By April, however, some of this same cheese had so deteriorated in quality that it was considerably poorer than was the fresh cheese then available on that market.

COMMENTS OF THE JUDGES

Comments by the men who scored the cheese in December follow:

Professor Fisk: "The qualities considered in the storage cheese were only the flavor and body and texture. The cheese scored in flavor very well. Most any of them would pass on the market as fresh cheese, for the average consumer would hardly know the difference between the storage cheese and the fresh cheese so far as flavor was concerned. The storage did not seem to affect the body and texture very much.

On the whole, I think that the cheese showed very good qualities, both in body and texture and flavor for cheese which had been in storage. So far as the commercial value of these cheese are concerned, it would seem to me that they could be sold as fresh cheese."

Professor Ross: "I was very agreeably surprised at the good quality of the goods after being held so long in storage. While there was a marked difference in some of the samples both in texture and flavor, yet the general quality of the cheese when considered as a whole was very uniform. With possibly three or four exceptions, I believe that the cheese we examined would go on the market and sell at good prices. It is my opinion that the quality of the cheese we examined demonstrates the fact that cottage cheese, when properly manufactured, may be held in storage for a long time without injuring its quality or flavor."

Mr. Tolstrup: "As far as I can judge, this cheese came out of storage practically in as good condition as when it was put in. While it did not have entirely the fine flavor of cheese just made, it is my opinion that it compares favorably with cheese which has been made for three or four days and kept under proper conditions in refrigerating plants. As such it would seem that storing would not injure its market quality to any noticeable extent.

It is my opinion that, providing the cheese is properly made and put into storage at once, there will be no difficulty in marketing it at nearly the ruling prices for fresh made cheese of the same nature."

Mr. Jones: "Regarding the holding of cottage cheese in storage for the purpose of handling skimmilk during the surplus periods, April,

May and June to the best advantage: I am convinced as a result of scoring some 90 samples of cottage cheese you had in storage that this product can be successfully stored without materially injuring its quality. It is my opinion that the best quality of storage cottage cheese is obtained by manufacturing the product from good quality skimmilk that has been pasteurized and making a fairly dry cheese."

MARKET VALUATION

All of the cottage cheese taken from storage and judged in December was repacked into barrels after the scoring and expressed to three different dealers in as many large markets. These shipments were made seven days after the cheese had been removed from cold storage. The dealers were purposely not informed that this was storage cheese for the reason that impartial comments and criticisms were desired, though not requested, of the dealers. Every firm accepted the cheese and paid the prevailing market price for it. In making returns one firm made no comment at all, another stated that the cheese was a little wet and a little too sour but otherwise fairly good and requested regular shipments even though the market at that particular moment was oversupplied owing to the Dairymen's League strike. The third firm accepted and paid the regular price for the cheese but was not fully satisfied for it wanted bakers' cheese whereas the shipment consisted mostly of pot cheese.

The neufchatel and cream cheeses were also barreled and shipped to a prominent manufacturer and packer of this kind of cheese, reaching him about 10 days after removal from storage. By this time it had developed a somewhat disagreeable flavor. He wrote that the cheese was good aside from its peculiar odor, but that he would not sell the cheese since his trade was a very discriminating one. The writer feels certain that if this cheese had been shipped immediately upon removal from storage instead of being held for a full week no such objection would have been made as to its quality. Furthermore it seems probable that it was the flavor of the cream cheese rather than that of the neufchatel which was objectionable.

KEEPING QUALITY OF THE COTTAGE CHEESE AFTER REMOVAL FROM STORAGE

The keeping quality of this cheese after being removed from storage was perhaps not quite as good as that of fresh cheese, although

several lots were kept at ice-box temperature for periods of from seven to ten days and were pronounced as good as fresh cheese kept for similar lengths of time. The high moisture samples deteriorated faster than did those which were dryer.

GENERAL CRITICISM OF THE STORAGE CHEESE

The most common criticisms of flavor of the 80 or more lots of cottage cheese were "high acid," "old" and "unclean," while less common comments were "bitter," "mouldy," "metallic" and "woody."

The neufchatel was mainly criticised as being "sour" or "acid," but some tubs were termed "old" and "slightly metallic."

The chief criticism of the cream cheese was that it showed "rancid or old fat flavor."

GENERAL OBSERVATIONS

When storing soft cheese it is very important that goods be selected which have been properly made and which possess a desirable, clean, mild acid flavor. It is advisable to make the cheese from pasteurized milk. The best results cannot be expected when cheese with off flavors, high moisture, or very high acid is stored. It is also important that the cheese be placed in storage as promptly as may be before any deterioration becomes apparent. It may be better to store it at or near the place of manufacture rather than to ship it a great distance, especially in hot weather when more or less unfavorable fermentations may set in. The cheese may then be removed from storage and shipped to market in a frozen condition if desired. The cheese should not be thawed too rapidly since high temperatures may cause leakage. A poor quality cheese should not be stored; the best should be selected for this purpose.

That many concerns are beginning to store considerable quantities of cottage cheese is indicated by government reports which show that 54 to 60 storages have reported holdings of 2,000,000 to 3,000,000 pounds on hand each month since last fall. Some firms store large quantities regularly during the flush season to be disposed of when there is a shortage. These for the most part are concerns which operate creameries. They utilize their surplus skimmilk by making it into cottage cheese and, having more than they can sell fresh, they have conserved the balance by freezing and holding till a shortage appears. Few actually go into the open market and buy for storage but this can be

done successfully if care is taken to secure cheese of proper quality.

Such plants as make a practice of shipping their cottage cheese in second hand butter tubs or in barrels would incur no extra expense for packages for storage except that such packages should preferably be paraffined and lined.

Storage charges vary in different sections and in different cities. A common city charge seems to be 25 to 30 cents per 100 lbs. for the first month and 15 to 20 cents per 100 lbs. for each additional month. At this rate it would cost from 1 to 1.3 cents per pound for a storage period of six months.

Last summer considerable quantities of cottage cheese were sold from country plants for less than three cents per pound and some could not be sold at any price, while later on in the season some dealers were obliged to pay at least six and seven cents per pound to get a supply. Such a margin is ample to cover shrinkage, storage, cartage charges, insurance and any additional package charges and still leave a profit.

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TIP BURN OF THE POTATO AND OTHER PLANTS

By B. F. LUTMAN

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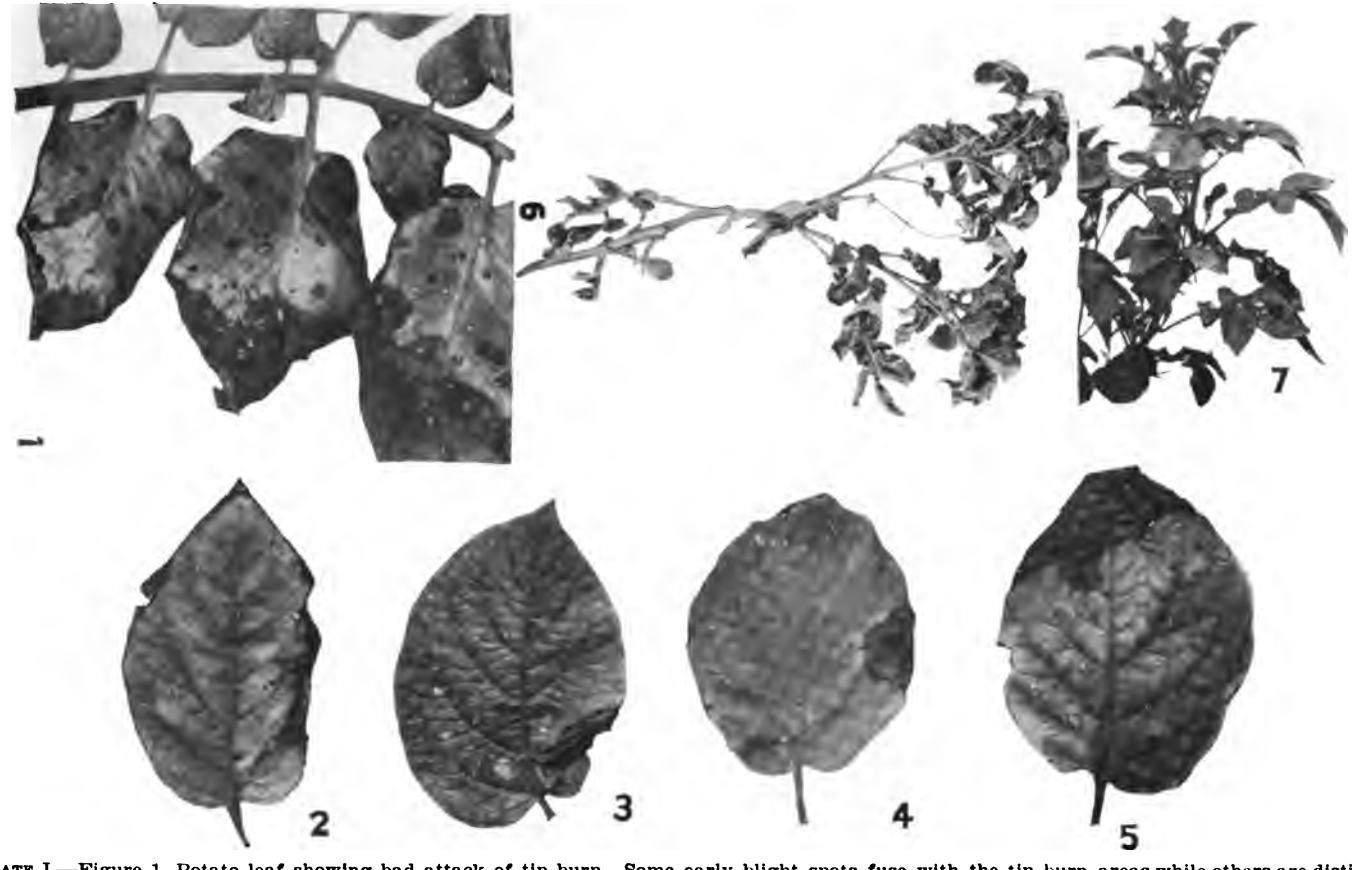

PLATE I.—Figure 1. Potato leaf showing bad attack of tip burn. Some early blight spots fuse with the tip burn areas while others are distinct in the middle of the leaflets. Figures 2, 3, 4, 5. Leaflets affected by tip burn; any portion of the leaflet may be injured. Figure 6. Potato branch taken from the field, August 17, 1917. Leaves from this branch are shown in text figure 4. Figure 7. Typical branch of potato plant just before blossoming. The upright position of the leaflets in the centre of the branch should be compared with the drooping, middle sized and older leaves.

PLATE II.—Figure 1. Tomato leaves showing tip burn during the summer of 1915. Figures 2 and 3. Bean leaves in same summer.

BULLETIN 214: TIP BURN OF THE POTATO AND OTHER PLANTS

By B. F. Lutman

SUMMARY

1. Tip burn of the potato is due to excessive heat and sunshine during late July and early August. An inordinate transpiration from portions of the leaflets directly affected results in a wilting from which the parts seriously injured do not recover.

2. The advance of the tip burn only occurs on hot brilliant days. During cloudy or cool weather it makes no progress.

3. Tip burn can be simulated in the greenhouse even in early spring by directing an excess of sunlight on any portion of the potato foliage.

4. The high osmotic pressure of the sap of the stalks of the plants as compared to that from the leaves undoubtedly aggravates this disease.

5. Tip burn may be largely prevented by shading and to some extent by the application of bordeaux mixture.

6. Early varieties are affected sooner and more seriously than late ones. The foliage of the latter often largely survives the weather producing tip burn and renews growth in September.

7. The removal of from 30 to 40 percent of the foliage by tip burn is not at all uncommon during July and August and even more than this is often lost by September 1.

INTRODUCTION

The lack of light seems to have impressed many students of plant diseases. Sorauer devotes a generous section in his "Handbook of Plant Diseases" (14) to this subject whereas all he has to say touching an excess of light is confined to three pages; indeed he does not deem the latter injury important enough to mention in his yearly summaries of plant diseases in Just's Jahresberichte. This will not seem strange to us when we remember that the study of plant pathology has been developed largely under European influence, and that under the northern European conditions with which these scientists were best acquainted it is undoubtedly true that lack of light is of more importance than excess of light. Owing to the high latitudes of these countries the sunshine is much weaker. Then, too, the peculiar atmospheric conditions produce a hazy, humid air. Clear, brilliant sunshine such as occurs during so many summer days in the North American forties is a rarity. The tropics ought to furnish many instances of injury to plants by excessive sunlight but the attention of plant pathologists does not seem to have been attracted to any extent in this direction, although Ewart (3) has made some interesting observations.

The acre production of potatoes in the United States is slightly less than 100 bushels whereas in Germany and England it is over 200 bushels. This lowered yield is due to a considerable extent to poor seed, improper cultivation, etc., but tip burn, on the whole, is the most important single limiting factor, except the Colorado potato beetle and the late blight. The extent to which the growing season is shortened and the amount of foliage is destroyed by tip burn, especially on the lighter soils and in the warmer portions of this country, is not likely to be appreciated, unless one actually spreads out the leaves and computes the destroyed areas.

The brilliancy of the sunshine during some parts of summer days in the temperate regions must almost approach that of the tropics. To be sure its intensity is not maintained for as long a period of time but it must be remembered that protracted exposure of foliage is not necessary to bring about a serious injury, especially of plants such as the potato cultivated out of their natural habitats. The potato flourishes wild in the shaded valleys of the mountainous regions of South America whence it originated. The air is relatively cool and hazy. The atmospheric conditions in North America during the growing season are in the main favorable to the growth and proper functioning of

the potato foliage, but during certain periods in the summer the light is almost tropical in its intensity and the potato foliage tips are scorched.

The first observations of tip burn in this country were made by Jones in Vermont (8) and Sturgis in Connecticut (16) in connection with studies on the early blight of potatoes. Sturgis (16) quotes a letter received from an extensive grower of potatoes in Pittsburg, Pa., as follows:

"For about six weeks there has been almost no rain; the weather has been very close and the sun hot. Under these conditions many potato fields have been wholly destroyed, those on sandy soil suffering most." Sturgis thinks "that extreme heat and dryness, accentuated by lack of moisture in the soil, may induce the death of tissues at a distance from the roots (the tips and edges of leaflets); that this damage may be increased and even initiated by the attacks of predatory insects (flea-beetles)." Jones (8) describes the disease as "characterized by the death of the potato leaves at their tips and margins, which portions dry, blacken and roll up or break off. This trouble has occurred quite commonly in Vermont during the dry, hot weather of midsummer in 1894 and 1895, and, as before stated, it was observed to a worse degree in Michigan and Wisconsin where the drought was more severe. In its earlier stages the dead tissues are often quite free from invasion by fungi, and even in the advanced stages the fungi present are chiefly saprophytes, i. e., such as live upon dead plant tissue only. It is attributable to the unfavorable conditions surrounding the plant, especially to the hot dry weather with insufficient water supply. It is aggregated by any other conditions which tend to lower the general vigor of the plant, such as insufficient food supply, attacks of insects and the early blight fungus. This difficulty has not been observed to any serious degree upon plants until after they pass the blossoming period, and naturally begin to weaken."

Goff (7) found in the summer of 1894 in Wisconsin that Everett's Heavy Weight, Rural New Yorker No. 2, Green Mountain and Everett's Colossal were very resistant to the heat, while some of the older varieties failed utterly. He suggests that the disease may be due to a reduction in the vigor of the older varieties and to be a symptom of "running out." A lack of moisture in the soil greatly aggravated the affection.

Occasional other references occur, especially in the literature of potato spraying. Lodeman (9) says that "plants grown upon dry

soils, those which are naturally warm and 'quick', are more subject to the disease than those grown in moister places in the same field. * * * * Water seems to be the one thing most needed." Stewart (16) makes frequent reference to this trouble near Geneva, N. Y., and attributes much to the beneficial results obtained from bordeaux spraying in preventing or retarding this disease. Similar results have been obtained at this Station (10) from the use of bordeaux on potatoes. In recent years we do not seem to hear as much of tip burn in potatoes although Fraser (5) states that in 1913 it was very severe in Quebec, "being favored by the dry weather, decreasing the vitality of the plants." Conservation of moisture and control of insects and fungi by spraying held the disease in check. No mention seems to occur in European literature of a similar disease; however Dr. W. A. Orton of the Federal Bureau of Plant Industry has informed the writer that he observed typical tip burn on the potatoes in Germany during the very dry summer of 1911.

Tip burn usually makes its appearance during late July or early August. The maturity of the plants, soil conditions, variety, preceding weather and growth have something to do with its destructiveness, but the principal factor seems to be heat and the intensity of the light.

Orton (12) in his interesting paper on the environmental influences which affect the health of the potato plant points out the fact that long, cool, equable summers are necessary for heavy potato harvests. The premature ripening of potatoes grown under the hot sun of the Southern States results in tip burn and in tubers which are constitutionally weak. It seems to be impossible to restore this vigor by a transfer to more favorable regions. Erwin (2) has found from a study of the normal temperatures during the growing season at Ames, Iowa, that the maximum was reached in the last ten days in July and that a second high point occurred during the middle of August. The crest of the heat wave is marked also by minimum humidity and maximum possible sunlight. He has found that under these conditions tip burn makes its most rapid progress.

Some authors have attempted to distinguish between tip burn and sun scald. Sun scald occurs when succulent, rapidly growing plants are suddenly subjected to intense sunlight and rapid evaporation. Tip burn is the result of protracted dry heat and hot weather on plants growing on light soil. Galloway's opinion (6) that all of these scaldings and burnings of the leaf are due to essentially the same cause is

undoubtedly the correct one as there are all sorts of intermediate forms.

A TYPICAL OUTBREAK OF TIP BURN ON THE POTATO

A description of a typical scorching of the leaves such as occurred July 20-August 6, 1917, will serve best to introduce this subject. The accompanying weather chart, figure 1, will make clear the rainfall, percentage of humidity, sunshine and maximum temperatures for the time covered by these observations.

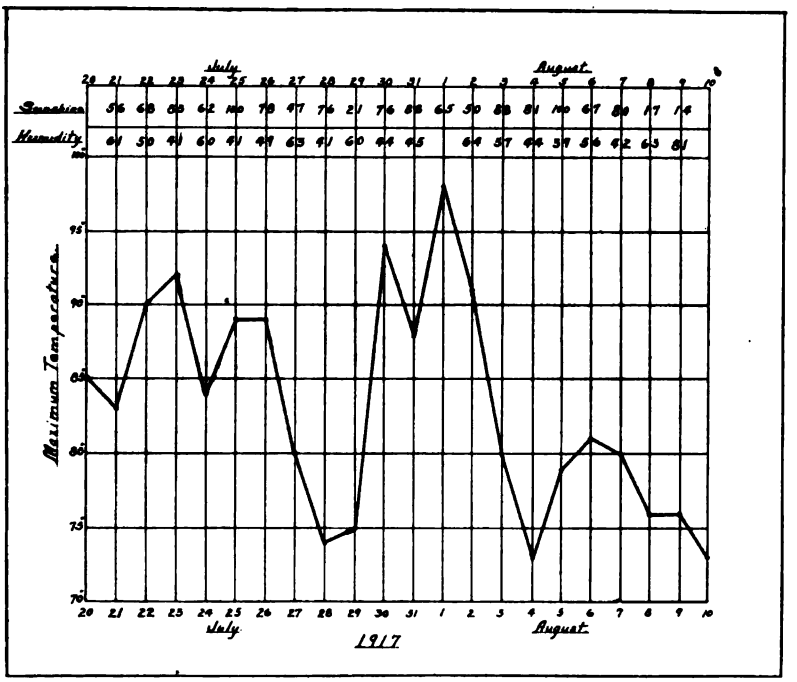

FIGURE 1.—Chart showing temperature, sunshine and humidity during a tip burn epidemic in late July and early August, 1917.

The weather, prior to July 20, 1917, had been practically normal, plant growth had been rapid and the Green Mountain variety set out about May 20 had nearly finished blossoming. The plants were not unusually large or succulent and a small percentage showed mosaic. July 22 was a very hot day and the effects on the foliage were marked on the following day which was again hot and clear. The advance of the tip burn on these days can be shown best by the figures of leaves drawn on July 23 and July 24 (figure 2). July 24 was much

cooler but sunny and the tip burn areas continued to increase in size: July 25 and July 26 were warm and sunshiny; July 27 was much cooler and cloudy during more than half of the time; and July 28 and 29 were also cool and without much direct sunlight. The advance of the tip burn was checked during the cooler days. The period covered by July

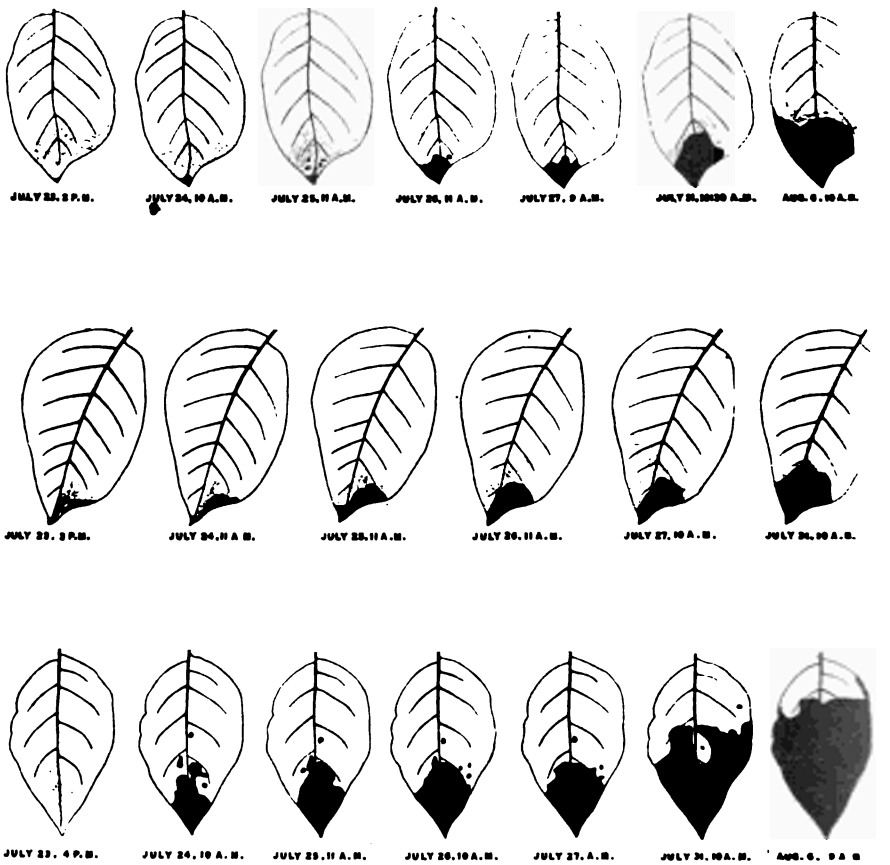

FIGURE 2.—Advance of tip burn on leaflets between July 23 and August 6, 1917

30, 31, August 1 and 2 was hard on potato foliage and many leaves entirely succumbed to the heat and sunshine. However, the advance of the malady during this latter period was much slower and less marked than during the first one and the drawings do not show the decided daily advance that occurred between July 22 and July 27.

The early stages of tip burn were found on the foliage on the morning of July 23. In most cases these indications were confined to

the ends of the leaflets which in the affected portions were paler than normal and presented a shrivelled or withered appearance. No large part of the leaflet at this time had turned brown. The brown area advanced into this paler portion gradually during the next four days. It was very evident that the leaf tissues had been injured in such a way that they never recovered entirely from the plasmolysis to which they had been subjected. The portion of this withered tissue that was least severely affected might have recovered if the weather subsequently had become more favorable, but the repeated witherings of the succeeding days completed its tissue destruction. The brown, dead portion in this way advanced into and finally covered practically all of the area that after the first unfavorable day had been only pale and withered.

The position of the leaves, as well as their age and maturity, seemed to have much to do with the presence and amount of tip burn. The first five or six very small leaves at the tip of the branches were not attacked but any of the older ones might show tip burn. Plate I, figure 7 sets forth the difference in the position of these leaves. The very young leaves stand upright and are not exposed to the perpendicular rays of the sunshine. The tips of the end leaflets of all the lower ones, however, bend over in such a way that at some time during the day they receive these rays at right angles. The older leaves droop so that not only the tips of the end leaflets are exposed but those of all of the leaflets may hang down and be struck by the tip burn. The oldest leaves are likely to be under the shade of those from the middle of the stem and so suffer less than those in the middle. If they are exposed at all they succumb readily and all of the leaflets die in a few days. The earlier attacks, however, are likely to occur on the middle leaves and after they have become thoroughly scorched and dead, the oldest leaves are exposed and in turn succumb.

The position of the leaves was especially noted during these observations as the amount of tip burn seemed to be dependent on the angle at which the sun's rays struck the end or side of the leaf. The maximum results were produced when the rays fell at right angles to the plane of the leaf. This condition is seen in figure 3. The tips or edges of the leaflets suffered more frequently than the portions of the leaf near its base as they were likely to droop into a position nearly or quite at right angles to the sun's rays. This position was not maintained for any long period of time, never over a few hours, as the

movement of the sun would make the retention of this position-relation very unlikely, but an exposure of even a half hour to an hour was all that was necessary to induce withering and the pallor which preceded browning and death.

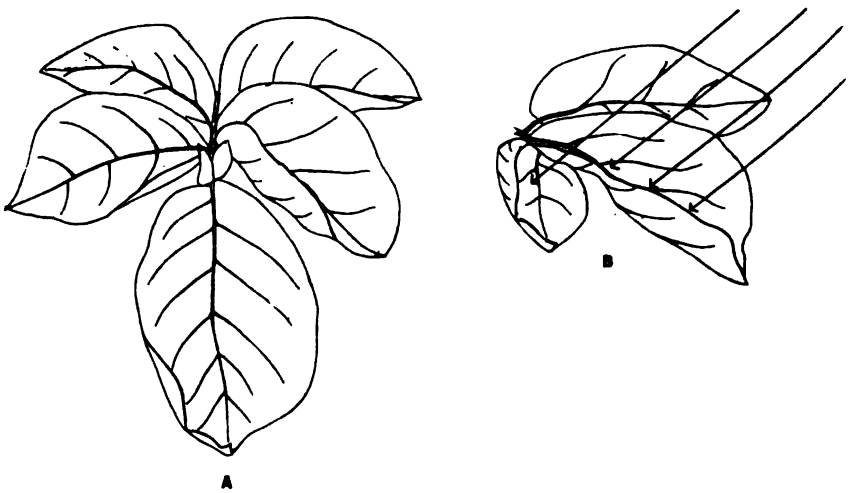

FIGURE 3.—Middle leaflet of Figure 2 showing its position in front view (a) and its relation to the rays of the sunlight at about 11 A. M. (b).

These effects did not seem to develop on the plants before nine o'clock as the sunlight does not acquire extreme intensity before that time, but the withering could still be noted after five. The leaves which suffered in the early part of the day were, of course, not the same as those affected in its latter part as the position of the sun brought different parts of the plant under its direct rays. The intense light and heat occurring between eleven and four seemed to produce, as might have been expected, the most severe cases and the most rapid advance of the tip burn.

The fact already noted by Jones (8) that maturity had much to do with the appearance of this disease was emphasized by observations on a plot of Green Mountain potatoes planted a hundred yards away on the same type of soil about a month later than the plot on which the present observations were made. These potatoes were not in blossom during the critical period of July 22-August 2, 1917, and no trace of tip burn was found upon them.

The lack of available potash during the past two or three years appears greatly to have increased the susceptibility of potato plants to tip burn especially if grown on the lighter soils. The plants seem to be

entirely healthy but at the end to be unable to stand up during the trying weather of August. No explanation is offered for this lack of stamina in potash-hungry plants but the observation can easily be made if part of the land has received manure or ashes while another part has received none.

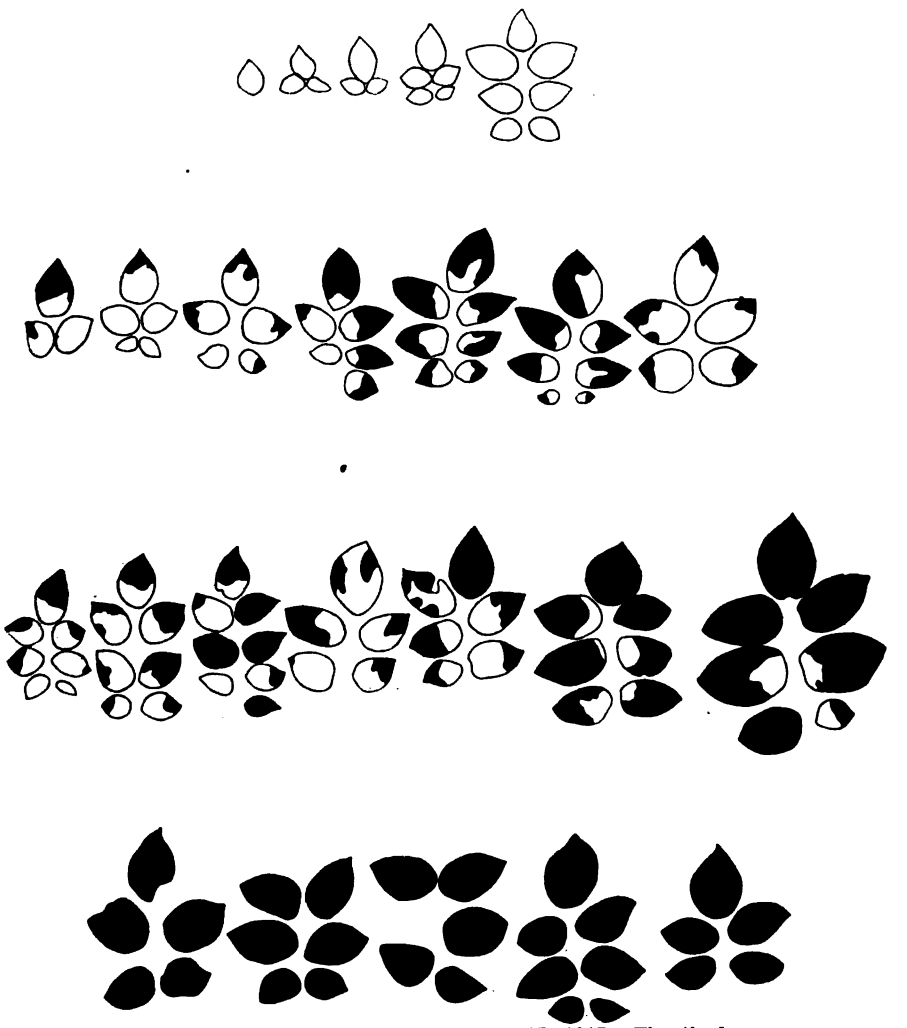

FIGURE 4.—Branch taken from field on August 17, 1917. The tip burn areas are represented in black.
(a) Leaves all alive.
(b) Leaves partly dead from tip burn.
(c) Leaves all dead from tip burn.

A casual inspection of a field will not reveal the amount of foliage lost from tip burn during an attack of the sort just described. On

August 15, quite a percentage seemed to be lost on a field of Green Mountain potatoes being grown by the local schools. It was thought by some of the school officials that the crop had been struck by late blight and the supervisor of the school plots was roundly taken to task for supposed neglect. No blight, however, was present, but a large percentage of the foliage was dead from tip burn. Three typical branches were removed, the leaves spread out and traced on paper and the area, living and dead, determined by means of a planimeter. The leaflets were divided into three groups:—all dead, all alive and partly dead. The following table gives the areas and percentages on the three stalks:

TABLE I. TIP BURN LOSSES.

	No. I		No. II		No. III	
	Area Sq. In.	%	Area Sq. In.	%	Area Sq. In.	%
Leaves, all alive.....	153.42	30.4	79.51	32.3	10.20	4.7
Leaves, all dead.....	118.16	23.4	86.93	35.3	46.23	21.4
Leaves, party dead						
dead area.....	68.72	13.6	22.06	8.9	51.13	23.6
live area.....	165.05	32.6	57.79	23.5	108.80	50.3
Total area, alive.....	318.47	63.1	137.3	55.7	119.0	55.0
Total area, dead.....	186.88	36.9	108.99	44.3	97.36	45.0

The drawings of one of the typical branches are shown in figure 4. Almost 40 percent of the total area of the foliage was dead on August 17 from tip burn. It is needless to add that the tuber yield was very small. The plant from which these drawings were made is shown in plate I, figure 6.

A study of a number of leaflets with reference to the position of the venation and the inroads of the tip burn make it plain that no relationship whatever exists between the two. If loss of water were the principal factor in tip burn, it is very evident that the portions of the leaf at the longest distance from the main veins would be first to suffer. The brown areas would extend into the leaf between these veins, whereas as a matter of fact they cut across the veins and veinlets as though they were not present (figure 5). Most of these brown areas occur at the tips of the leaflet and occasionally at the sides but rarely at the base. The browning of a leaflet on the side (plate I, figure 5c and figures 2 and 4), only occurs if this portion is uppermost or is rolled up so as to present it at an appropriate angle to the action of the sunlight.

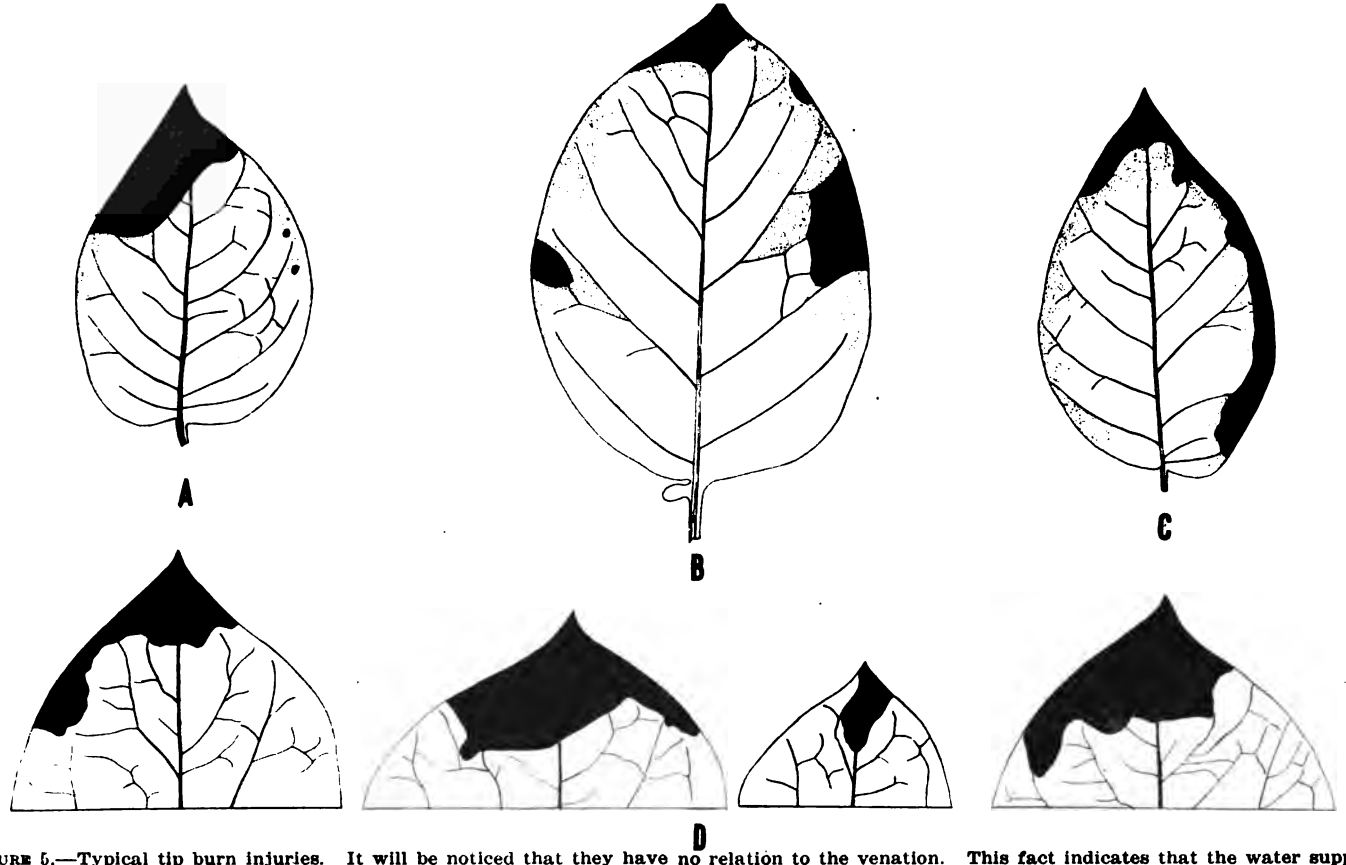

FIGURE 5.—Typical tip burn injuries. It will be noticed that they have no relation to the venation. This fact indicates that the water supply is not the factor of fundamental importance while heat and sunshine are. Leaflets A, B and C were rolled up. The left hand side of A was uppermost and exposed to the sunlight; the two edges of B were rolled together and about equally exposed; the right hand edge of C was rolled so as to be exposed to the sunlight. The leaflets D were not rolled to any extent.

VARIETAL RESISTANCE TO TIP BURN

The early varieties of potatoes are much more susceptible to tip burn than are the later ones; in fact the death of foliage in the former is usually due in this region to severe attacks of tip burn. Our so-called late varieties suffer but they retain enough of their foliage so that they continue growth and tuber formation during September and early October, after the extremely hot weather of August. The yield of tubers is very light from those varieties that tip burn readily. Indeed it is doubtful if it is wise to attempt to raise varieties like Triumph. Other early varieties, such as Early Rose, Early Ohio, Bovee, and Irish Cobbler, lose a considerable part of their foliage but enough leaves remain green and active so that yields are fair, but they never approach those of the standard late Green Mountain, Rural New Yorker or Vermont Gold Coin.

FIGURE 6.—Normal chlorophyl bodies at left; chlorophyl bodies from yellow zone around the tip burn area at the right.

Observations were made during the summers of 1914, 1915 and 1916 on a number of varities grown on light sandy soil. The weather charts for the growing period of these years are shown since a clear understanding of the weather conditions is impossible without them.

RESISTANCE OF POTATO VARIETIES TO TIP BURN IN 1914

At least three periods were observed during which the plants growing in pots were affected by tip burn. The first of these was the week including July 14 and 15. It will be noted on the accompanying chart of maximum temperature (figure 7) that between July 13 and 17

the thermomenter often nearly reached 88° F. These plants continued slowly to die during August. The marked advance in tip

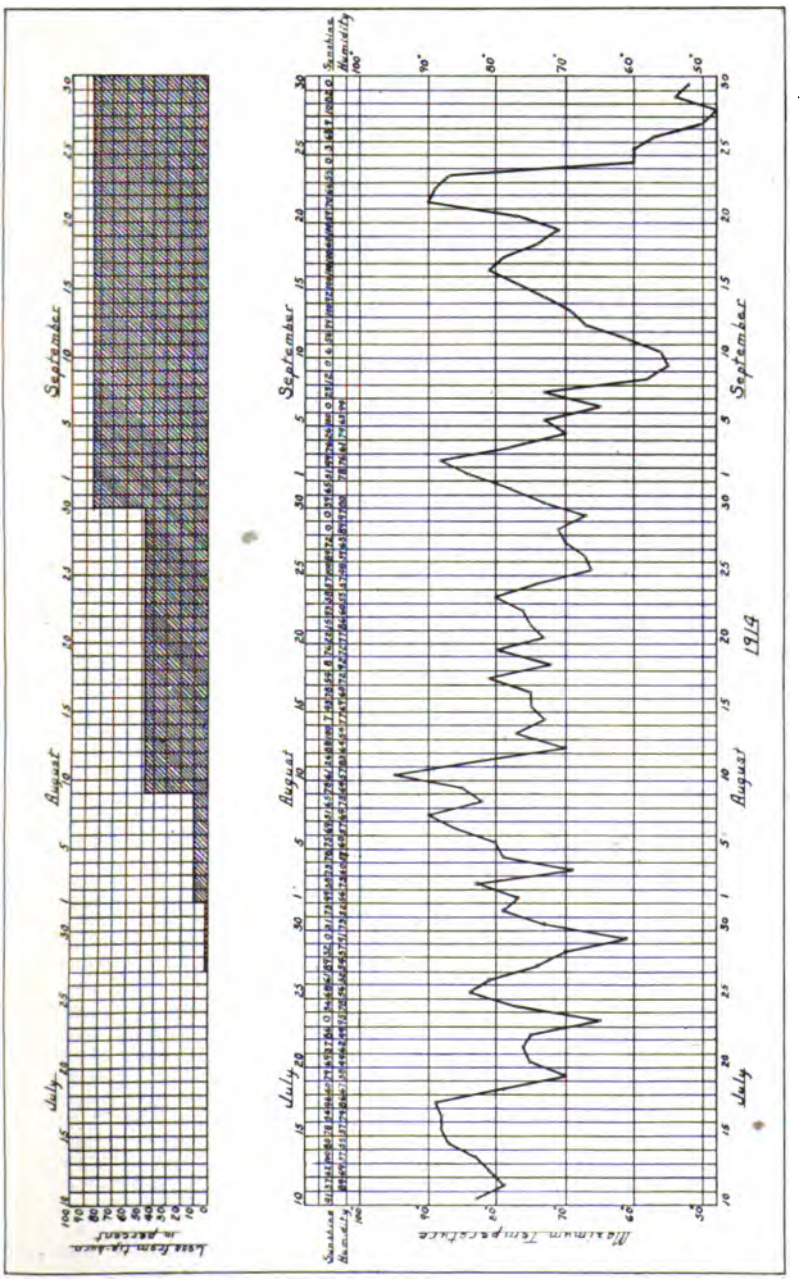

FIGURE 7.—Chart showing sunshine, humidity and maximum temperatures for 1914.

burn on other plots that were used for spraying experiments oc-

curred during the last week in July. The chart shows that this was a period of very warm weather. On one day in the next period (August 10) the thermometer rose to 94° F. During this time much of the foliage died on the unsprayed plants that were being grown for the study of scab of the lower land. The disease was first noticed on some of the varieties on July 27, although it may have occurred a few days earlier. It was not noted until about the first of September on Green Mountains planted late in June, when the thermometer again rose to 86° F. These observations would seem to point to the conclusion that the onset of the death of the tips was conditioned by two factors, namely, variety and maturity and condition of plants. Early varieties show the trouble before the later ones, but this may be conditioned by the second factor. An examination of the plants beginning to suffer from tip burn showed, in some instances at least, tubers about the size of a hulled walnut. The succulence of the plant also seems to hasten the trouble.

The plants were dusted frequently with paris green and slacked lime but were not sprayed with bordeaux. The land was a light, sandy piece, the east end of which was considerably higher and more exposed to the north and south winds than was the west end. The following table shows the percentage of foliage estimated to have been lost during the warmer part of the summer. The attempt was made to visit the field and make an estimate after each important advance of the tip burn.

TABLE II.—RESISTANCE OF POTATO VARIETIES TO TIP BURN IN 1914.
Percentage of foliage (estimated) dead from tip burn.

	August 1		August 8		August 30	
Variety	West end	East end	West end	East end	West end	East end
Vermont Gold Coin	15-20	20-25	50-60	95	98	99
Irish Cobbler	15-20	15	80-90	80	100	100
Cowhorn	2-5	10	30-40	30-40	98	98
Million Dollar	1-2	2-3	15-20	30-40	90	95
White Ohio	5-10	25-30	80	95	100	100
Cambridge Russet	1-2	5	20-25	50	90	98
Triumph	50-75	50-75	98	100	100	100
Early Ohio	5-10	15	50-60	50	98	99
Dibble's Russet	1	5	10-15	25	40	50
Dakota Red	3-5	3-5	40-50	15-20	50	50
Rural New Yorker No. 2	2-5	2-3	5-10	10-15	50	50
Scab Proof	5-10	3-5	50-60	50	95	95
Twentieth Century	10-15	10-15	80	50	100	99
Beauty of Hebron	10	5-10	20	30-40	90	90
Bovee	10-15	10-15	60	75	100	99

Pride of Vermont	5-10	3-5	30-40	20-25	85	90
Norcross	10	5-10	30-40	30	85	90
Early Rose	15-20	20	40-50	60	99	99
White Star	10-15	5-10	40-50	60	95	98
Burbank's Russet	2-3	5	30-40	30-40	80	98
Canadian varieties*	0	0	0-5	0-5	10-20	10-20

*Planted June 18; Davies' Warrior, Moreton Beauty, etc.

RESISTANCE OF POTATO VARIETIES TO TIP BURN IN 1915

June and early July, 1915, were dry although the drought was not as severe nor as prolonged as that of June, 1914. Abundant rains and saturated atmosphere during the middle of August induced an epidemic of late blight which was checked by the drier weather of late August.

The first tip burn was noted in the week July 25-31. Early Rose, planted early in May in tiles, showed marked tip burn at this date. The several varieties had been planted on the same land on May 20. The weather conditions are shown in the accompanying chart (fig. 8).

TABLE III.—PERCENTAGE OF FOLIAGE ESTIMATED DEAD FROM TIP BURN, SUMMER 1915.

Variety	July 29	Aug. 13	Aug. 23	Sept. 1
Green Mountain	0	0	5	30-40, early blight
Norcross	0	traces	5	30-40, early blight
Rural New Yorker No. 2	0	traces	5	75, early blight
Early Rose	0	15-20 plants yellow	90	100
Irish Cobbler	0	50 plants yellow	100	100
Scab Proof	0	traces	10-15	60
Beauty of Hebron	0	5	10-15	50
Dibble's Russet	0	traces	5-10	40
Vermont Gold Coin	0	10-15 plants yellowing	15-20	50
Million Dollar	0	traces	10	30
Bovee	0	40 plants yellow	100	100
Davies Warrior	0	traces	traces	traces
Early Ohio	15-20	plants yellow	90	90
Dakota Red	0	traces	5-10	60
Pride of Vermont	0	0	10	30-40
Cowhorn	0	10	25-30	90
White Ohio	5-10	60-70 plants all yellow	100	100
Burbank's Russet	0	traces	5	30
White Star	0	traces	10-15	30
Triumph	50	95	100	100
Cambridge Russet	0	traces	10-15	75

The advance of the tip burn between August 13 and 23 was very great, especially on the early varieties. Irish Cobbler, Bovee, White Ohio, and Triumph were all dead and Early Rose and Early Ohio nearly so. It also made rapid progress during the week August 23-

September 1. At this date, a little early blight also appeared at one side of the plot.

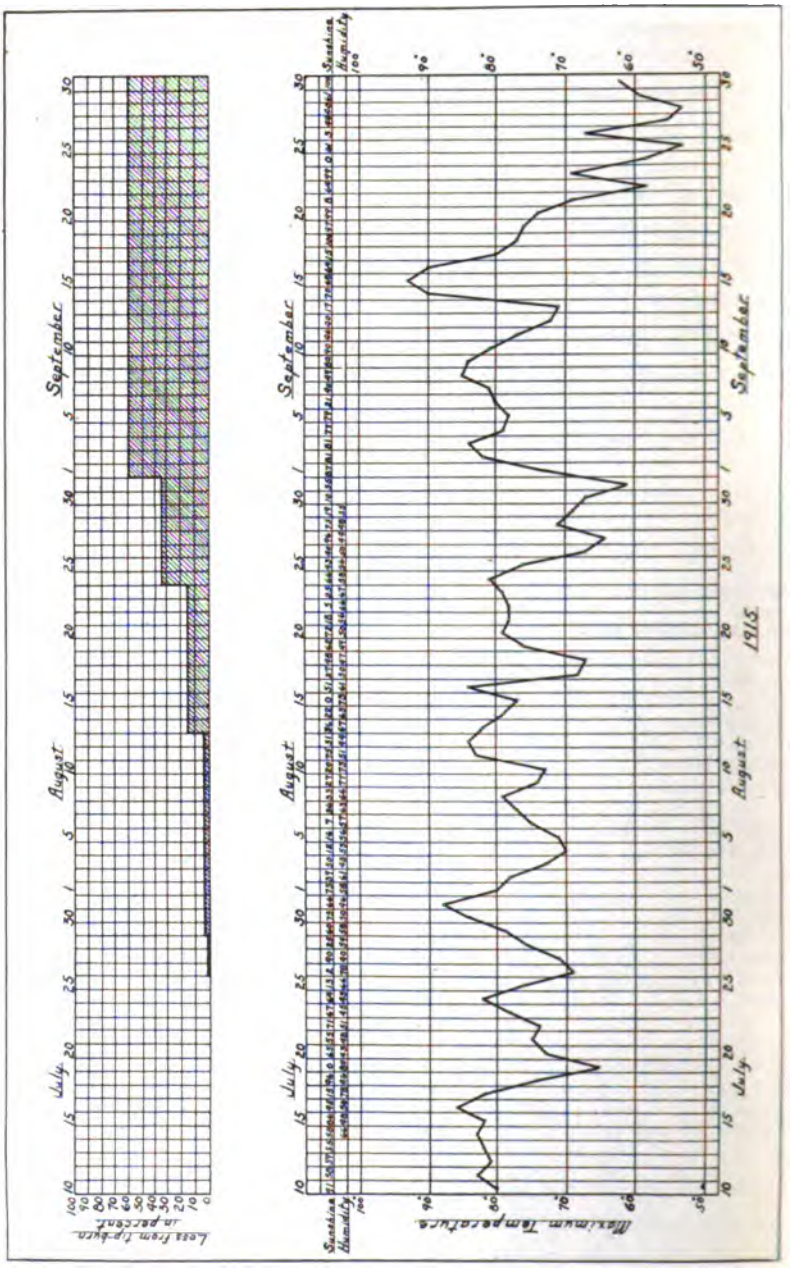

Fig. 10. Chart showing sunshine, humidity and maximum temperatures for 1915.

RESISTANCE OF POTATO VARIETIES TO TIP BURN IN 1916

The season of 1916 was a very abnormal one (figure 9). Tip burn began to show itself at an unusually early date and the plants were practically all dead by the end of August. The first onset was noted on July 24 when Triumph had lost about 25 percent of its foliage. The very hot weather of July 20-22 was undoubtedly responsible for this situation. Hot weather and brilliant sunshine on August 7 advanced the tip burn greatly and a field of Irish Cobblers located near these plots lost a large percentage of its foliage in one day as a result of this condition. Very hot weather between August 15 to 25 completed the destruction on many of the varieties.

The following table sums up the observations:

TABLE IV.—RESISTANCE OF POTATO VARIETIES TO TIP BURN, 1916.

Variety	Aug. 1	Aug. 11	Aug. 30
Green Mountain	traces	traces	50
Cambridge Russet	traces	traces	50
Triumph	50	90	100
White Star	20	20	100
Burbank's Russet	0	0	40
White Ohio	traces	15-20	100
Cowhorn	0	0	40
Pride of Vermont	50	50	100
Dakota Red	traces	traces	30
Early Ohio	0	0	30
Davies Warrior	0	0	5
Bovee	0	50	100
Million Dollar	traces	traces	20
Vermont Gold Coin	traces	traces	30
Dibble's Russet	traces	traces	40
Beauty of Hebron	traces	traces	20
Scab Proof	0	0	50
Early Rose	20	20	100
Norcross	0	0	50
Reading Russet	0	0	100
Sir John Llewellyn	0	0	100
Irish Cobbler	5	5	100

The varieties on which the above observations were made were planted on light sandy soil. An interesting comparison may be made between them and a nearby field of Irish Cobblers on heavy clay loam. No tip burn whatever had appeared on this latter field on August 12, while the Irish Cobblers grown on a lighter soil type were half dead. On August 30, however, the foliage on the unsprayed plants on the clay was half dead. The sprayed plants were not as severely affected. This sudden advance of the tip burn took place between August 25 and 28, when the sunshine was very brilliant, although

there was not an unusual amount of it nor was the temperature very high. On September 8, the unsprayed foliage was between two-thirds

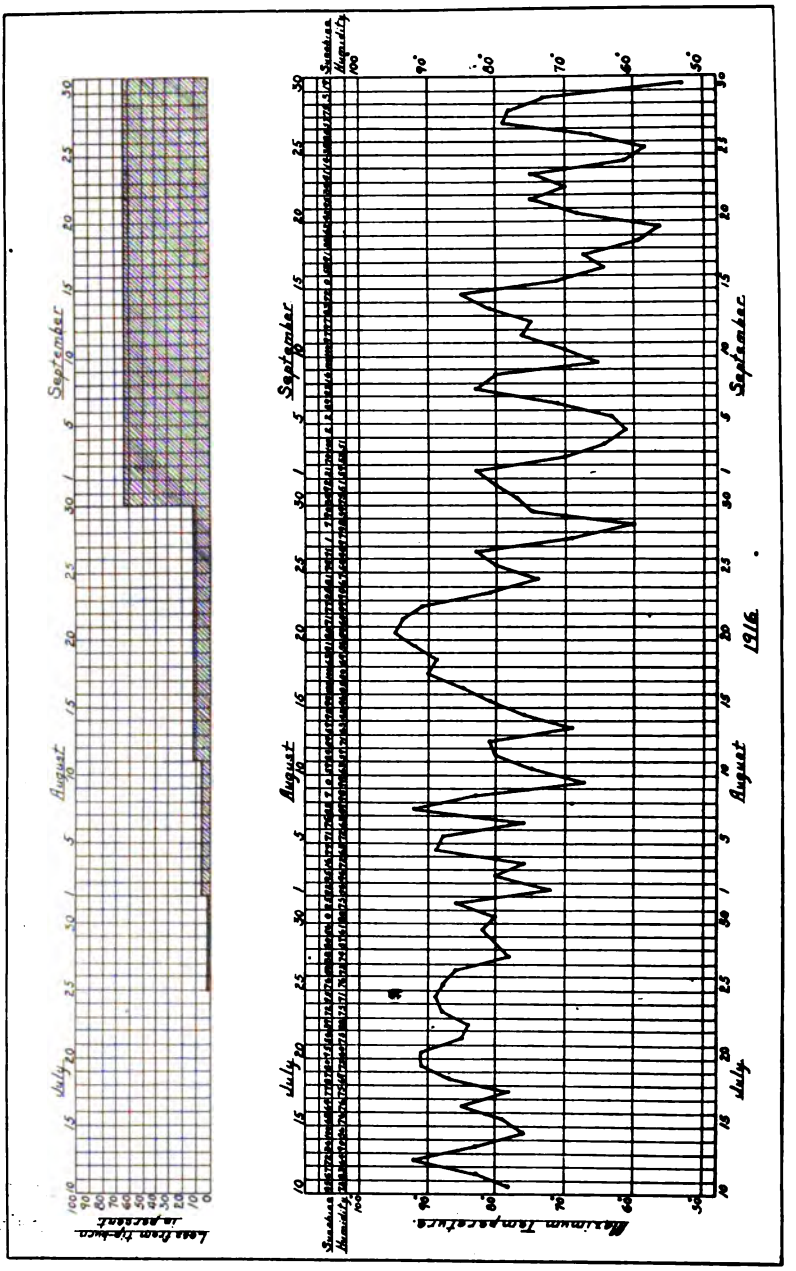

FIGURE 4. Chart showing sunshine, humidity and maximum temperatures for 1916.

and three-fourths dead, the increase having occurred when the temper-

ature was extreme and the sunshine brilliant. During the following two weeks the plants slowly died but not as rapidly as during the hot week, and all were dead by the first of October.

THE ARTIFICIAL PRODUCTION OF TIP BURN

Field observations have made the fact clear that potato plants grown in sandy soils and in dry situations are always more subject to this trouble than those grown on clay loams or in situations where more water is available. Plants grown in the greenhouse in the spring in very dry situations, however, showed no trace of tip burn. A hot-house bed was filled with sand, a minimum amount of fertilizer applied, and humus and potatoes planted. The plants came up with slender stalks and thin leaves. One end of the bed was kept very moist while the other end was given only enough water to keep the plants just above the wilting point. These plants were grown during April and May without any tip burn appearing, although the plants at the dry end of the bed were allowed to wilt several times. The entire foliage would become flaccid and droop, but the tips of the leaves would not die. When the plants were again given water, they recovered their turgidity, but if the wilting was allowed to go on too long, the entire plant turned brown and died. Tip burn, therefore, does not seem to be a condition brought about by the general lack of water but by too small a quantity at local areas of the plant where it has been subjected to an abnormal water loss resulting from brilliant sunshine.

The failure to produce tip burn under these conditions may be ascribed to:

(1) The weaker sunlight of April and May.

(2) The immaturity of the plants.

(3) The weakening of the light by its passage through glass. Stone (15) has shown that the amount of light is reduced between 13 and 36 per cent in greenhouses. The production of tip burn on plants grown on heavy clay loams with an abundance of water will be discussed under the shading experiments described later.

This attempt at a generalized artificial production of tip burn having failed, experiments were started with a view of bringing about this condition locally. The necessary factor to introduce apparently was an excess of sunlight on a small area of the leaf. Sunlight may act either chemically to cause the destruction of important leaf constituents, e. g., chlorophyll, or it may so warm the leaf as greatly

to accelerate the loss of water. A separation of the two actions is difficult in a practical way. The concentration of the light of the sun on a particular part of the plant for a considerable period of time in itself is not easy. The separation and elimination of the heat rays from the light, chemical and other rays by passing them through a layer of water was found to be an even greater obstacle. The effect of the sun's rays on the plant is without doubt due both to the heat and the light rays, and, indeed, the others may function in this respect, but no feasible method was available for their complete separation..

The light rays were concentrated at a given point by the use of three mirrors on a heliostat. These mirrors, each about 10 by 15 cm. in size and of the best plane glass, were so arranged in frames that the light from all three could be focussed on one spot. With a little attention it was possible to keep the light from the three mirrors in one place for a half hour or more. This time doubtless is not as long as that in which the sunlight acts on the foliage during the warmer part of the day from eleven to one, but on the other hand the intensity of the light was about twice as great as that of unconcentrated sunlight. Allowing a third for the absorption of light by each of the mirrors, the light rays which impinged upon the leaf surfaces would still be about doubled in intensity. This was true of the heat rays as well as of the light rays, for a thermometer held in the spot of concentrated light registered from five to six degrees C. higher than it did when placed in the direct sunlight. In this way the intensity of the light could be increased almost three-fold since a good mirror only absorbs a small percentage of the light which falls on it. A large concave lens would have concentrated the light in a similar way but by the use of the three mirrors it was possible to turn one of them away and only utilize the light from two.

A potted potato plant was placed on a support in front of the heliostat and the particular leaves to be exposed were held in such a position that the light could be focussed on them. The exposures continued from 10 to 30 minutes, lasting usually about 15 to 20 minutes. They were made during the warmest part of the day, between ten and three. As far as possible an entire leaf or an entire large leaflet was covered, but inevitably the action of the light was very uneven. The angle at which it struck the leaflet seemed to determine the intensity of its action.

The exposure was not continued much beyond the point where pronounced wilting occurred in some portion of the leaflet. The leaflet was then marked with a tag on which the location of the most seriously affected area was indicated, and the plant was set aside until the following day. If the exposure was continued over the entire leaflet a little too long or the heat was too intense, a considerable portion of the wilted leaf died as a result; and if the area of application was limited only the margin or tip dried up.

An examination of a plant after it had been thus treated evidenced the marked similarity of this artificially produced tip burn with the natural one. The changes produced by the reflected light are much more rapid and violent but they are unquestionably of the same nature as those wrought in the field under the influence of intense midsummer sunlight. The excessive light and heat brings about so abnormal loss of water that the cells lose their turgidity to such a degree that they cannot recover. Wilting is the external evidence of this condition. The excessive heat and light also produce destructive chemical changes in the chlorophyll and it is entirely possible that these changes precede the loss of water.

THE PREVENTION OF TIP BURN

Various attempts were made to prevent tip burn on small plots of potatoes either in beds or growing in large tiles. Since tip burn is the result of the lack of water, two methods of supplying or conserving water were used, namely:

(1) To furnish to the plant roots an abundance of soil water by frequent waterings.

(2) To shade the plants during late July and early August in order to conserve as much as possible the leaf moisture and prevent excessive transpiration.

The application of an abundance of water to the roots during the heat of the summer did not avail to lessen tip burn. The plants became more succulent but tip burn attacked them about as actively as it did those growing with only the normal rainfall. The shading experiments were more successful. A heavy cheesecloth screen was stretched in the form of a tent over some 20 large tile containing the plants. An abundance of water was supplied to the roots, the foliage was succulent, the growth rank. The plants were untouched during late July and early August while the branches which escaped this pro-

tection and grew out into the open sunlight were injured to nearly the same extent as the plants in the open, which lost at least 40 percent of their foliage during early August. Clearly the protection furnished by the screen must have been of great importance in retarding the advance of this malady. Later in August, the cheesecloth screen did not cut off enough light and the foliage showed considerable tip burn although never as much as did the plants in the open.

The field prevention or, at least, lessening of tip burn by the application of bordeaux has been discussed elsewhere by the writer (10). The shading effect of bordeaux emphasized by Schander (13) would seem to play an important role in its beneficial effects on potatoes in the Middle Northern States.

The shading of tobacco by means of cloth screens in the fields, especially in the tropics, is a well established practise. It is used doubtless not so much with a view of preventing tip burn as of securing a rank leaf full of moisture, which, on drying, becomes very soft and pliable. The writer is not aware that tobacco plants suffer at all from tip burn.

WHY DO THE VERY YOUNG LEAVES AND YOUNG PLANTS ESCAPE TIP BURN?

The upright position of the youngest four or five leaves (plate I, figure 7), helps them to escape the influence of the direct rays of the sun. The concentration of cell sap is undoubtedly quite a little greater toward the growing point of the plant than it is in other portions. This can be easily verified by plasmolyzing sections from the very young leaves in potassium nitrate solution for comparison with those from the lower part of the stalk. A potassium nitrate solution of 2.5 to 3 per cent concentration will plasmolyze the cells from the lower leaves while a solution of 3 to 3.5 per cent concentration is necessary to produce this condition in the very young tip leaves. The higher osmotic pressure in these portions can also be demonstrated by cryoscopic methods.

The higher osmotic pressure also produces a marked effect on the loss of water from the tips of the plants. If both young and old leaves are removed from the plant, weighed and allowed to wilt, the latter lose much more in weight than the former.

TABLE V.

	Weight at 10:30 A. M. grams	Weight at 3:30 P. M. grams	Loss grams	Loss %
11 old leaves	35.3	21.5	13.8	39
32 young leaves	22.3	17.5	4.8	21
	Weight at 10 A. M.	Weight at 12 M.		
6 old leaves	29.3	25.0	4.3	15
25 young leaves	19.0	17.3	1.7	9
	Weight at 3:30 P. M.	Weight at 5:30 P. M.	Loss	
7 old leaves	35.5	30.3	5.2	14½
30 young leaves	20.8	18.7	2.1	9

The evaporating surface must have been very much larger in the small leaves than in the large leaves per gram of weight. This emphasizes still more the retention of the moisture by the former. The leaf injury undoubtedly is due not only to tissue scorching but also to its plasmolysis, and it is the latter which in the main is responsible for the disastrous results.

The remarkable changes which occur in the relative osmotic pressures in the various organs of the potato plant during and before the critical period when the tubers are growing have been elsewhere presented by the writer (11). During the early portion of the season the osmotic pressure is highest in the foliage of the young plants. The plants at this time are growing in size by increasing the amount of foliage. With the oncoming of the blossoming stage, however, the stalks develop the highest osmotic pressure, especially on hot dry days. The natural consequence must be that the cells of the stalk pull water from the leaves as well as from the roots. Since the leaves are already suffering from excessive transpiration the combination of losses results in tip burn. The high osmotic pressure that develops in the stalks at this time is due to their temporary storage of sucrose and of glucoses. These products are the result of the very active assimilation of the leaves in the hot sunshine, and the high pressure in the stalks is to be regarded as an entirely normal condition. On cloudy humid days, the pressure in the stalks tends to subside and a nearer approach to equilibrium becomes established as between stalk and foliage. The advance of the tip burn then stops. The plants often put out a little foliage late in the autumn. The sap of these new leaves possesses a higher osmotic pressure than that of any other part of the plant and no tip burn appears. The concentration of the cell sap is greater in the leaves of the old plants than it is in the younger ones but the difference is not enough

to prevent the leaflets from suffering from tip burn. Very old plants have, a low osmotic pressure in their cell sap due to the withdrawal of sugars and salts to the tubers where they are deposited.

The color of the leaves seems to determine to some extent the liability to tip burn provided conditions become favorable. The varietal test results show that those varieties that are recorded as having yellow foliage had lost a considerable portion thereof on the date next subsequent to that on which observations as to yellowing were made. Many of the varieties yellowing in this way were of the early type and had apparently reached a certain stage of maturity. The yellow color may indicate the destruction of chlorophyll to form carotin, since many of these leaves showed very little of the green constituents of chlorophyll in solutions made from them. Ewart's (4) interesting theory would seem thus to secure some corroboration. In diffuse daylight or in illumination that is not too intense, the chlorophyll is constantly reformed as it is broken up by the action of the sunlight. so that the brilliant dark green color is maintained; but in very brilliant sunlight destructive action is more rapid than constructive action and carotin becomes the dominant constituent. The yellowing leaves are usually among the older ones so that the age of the leaf and of its chlorophyll may play some role in its ability to stand up under intense illumination.

Some exceptions have been observed. The foliage of the potato plants on very low, wet soil in 1915 was pronouncedly red, while similar plants in the same rows on higher lighter sandy soil escaped. Very hot weather a few days later affected these reddened plants much more seriously than the normal plants. The red portions of the leaflets were always the parts that died first from the tip burn.

The foliage of the majority of the varieties turned yellow when they were on the decline but Dakota Red was a pronounced exception. the foliage assuming a red tinge before succumbing to tip burn.

The tissues immediately adjacent to the brown area in tip burn is often of a yellow-green color. This seems to be an indication of an incomplete recovery from wilting combined probably with decomposition of the chlorophyll to the constituent carotin. The brown area advanced rapidly into its surrounding yellow-green zone if conditions become favorable for the increase of the dead portion.

TIP BURN ON OTHER PLANTS

The foliage of the potato seems to be especially subject to the destructive action of brilliant sunlight, doubtless because of its succulence and to the fact that it has never recovered from its original tendency to grow best in shade-loving habitats. Very hot summers, however, or unusual succulence sometimes brings about similar conditions in other plants. Lettuce, both in the greenhouse and in the open air, often shows a burning or scalding of the tips of the leaves, which is undoubtedly the result of too much light and if excessive, seriously reduces market values. Certain varieties, such as Grand Rapids, are fairly resistant to this trouble. During the summer of 1915, tip burn was noted on bean (plate II, figures 2 and 3), onion and tomato (plate II, figure 1) plants growing on very light sandy soil. The tomato, although closely related to the potato and having the same type of succulent leaves, does not usually suffer from tip burn. One difference was observed in these tip-burned leaves on the tomato plants as compared with potato foliage, namely, that the affected area instead of being located on the margin of the leaflet at times was found nearer the center. Other plants are undoubtedly subject to tip burn and further search might lead to the discovery of this trouble on almost all cultivated forms.

THE BREAKING DOWN OF PLANTS UNDER STRESS

Tip burn illustrates an important principle in plant physiology and pathology that has not been sufficiently emphasized. This principle probably underlies most pathological physiology. Plants may grow and thrive under normal or fairly normal conditions and all of their life functions may be correlated and working smoothly. Then suddenly a few days or even a few hours of violent change may bring about the entire suspension of some one or more of these functions and greater havoc may be played in a short space of time than had been wrought by all the minor fluctuations that the plant has previously encountered. It is not the little adversities that count, because the plant usually has a chance to recover from such shocks unless they are repeated frequently and are of the same general character. Violent changes on the other hand throw the apparatus so far out of equilibrium with one sudden thrust that there is no opportunity for partial recovery and partial death results. Burns (1) has pointed out similar facts regard-

ing the tolerance of forest trees to light. Diseases resulting from the invasion of plants by fungi and bacteria to a less marked degree have their origin, also, in periods when the conditions are at their optimum in favor of parasitic attack. The breaking down of plants under stress, however, is particularly noticeable in those derangements that we class as physiological diseases.

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RESISTANCE OF POTATO TUBERS TO SCAB

By B. F. LUTMAN

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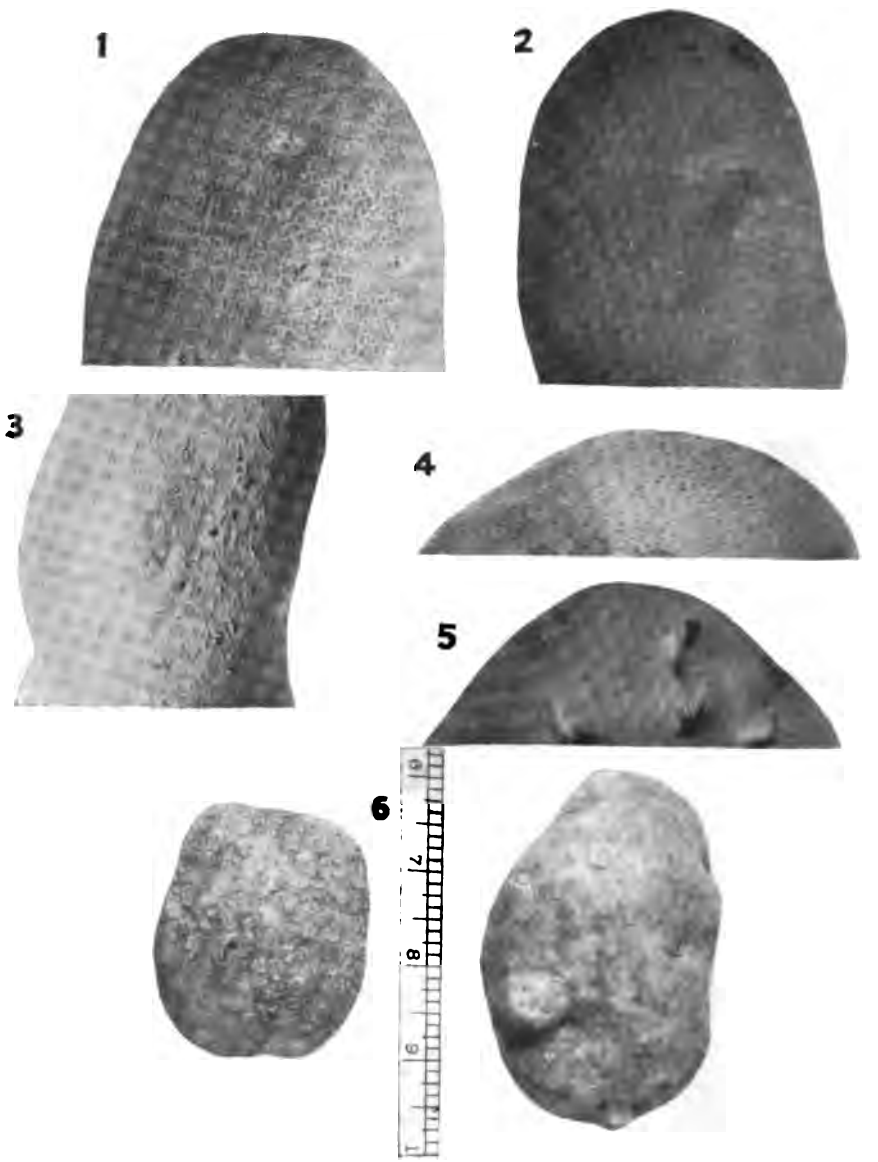

PLATE I.—Figure 1. Skin of Scab Proof. Figure 2. Skin of Cambridge Russet. Figure 3. Skin of Cowhorn. Figure 4. Skin of Rural New Yorker No. 2. Figure 5. Skin of Dibble's Russet. Figure 6. Peculiar russetting of Irish Cobbler.

BULLETIN 215: RESISTANCE OF POTATO TUBERS TO SCAB

By B. F. Lutman

Several investigators have made observations as to the amount of scab found on potato tubers. These records in most cases were incidental to tests of new varieties, yields, eating quality, etc., but they serve to indicate the amount of scab occurring under widely diverse environments and throughout a long series of years.

Beckwith (1) at Geneva, N. Y., tested 45 varieties during the dry growing season of 1887. He concluded that the tubers of dark-skinned varieties show less scab than those of the flesh-colored skin types and more scab than do tubers with relatively white skins, the figures being respectively 27, 53 and 43 percents.

Humphreys (11) in Massachusetts, in 1890, testing 14 varities, found Rural New Yorker No. 2 and White Seedling to be comparatively free from scab but was unable to detect any greater resistance in the thick skinned or red skinned sorts.

Kinney (13) in 1891, in Rhode Island, deemed some of the five varieties he tried more susceptible than others.

Rane and Hunt (17) in New Hampshire, noted the amount of scabbing on a number of varieties. Bliss' Triumph (32 percent scab) seemed more resistant than Green Mountain (72 percent scab).

Williams (20) in South Dakota, in 1894 and 1895, tested 21 varieties as to their scab resistance. Marked differences were noted, "the thicker skinned, dark colored varieties being less likely to suffer severely from scab than the paler colored, thin skinned ones."

Craig (4) at the Canadian Experimental Farms, in 1896, observed that Northern Spy was only slightly affected by scab while more than 90 percent of the Clarkes' No. 1 tubers were scabby.

Halsted (9) in New Jersey, in 1898, arranged the seven varieties he tested, beginning with the more resistant, as follows: (1) Rural New Yorker No. 2, (2) Rural Blush, (3) American Giant, (4) Queen, (5) June Eating, (6) Delaware, (7) Early Rose. He notes also that the deep scab is more common on the latter than on the other varieties. In 1899 he (10) similarly arranged seven varieties as follows: (1) State of Maine, (2) Queen, (3) White Star, (4) Early Rose, (5) Hebron, (6) Rural New Yorker No. 2, (7) Green Mountain.

Shepperd and Ten Eyck (18) in North Dakota, in 1902, tested 27 varieties. Four developed no scabby tubers, while there was from 64 to 78 percent scab on five varieties. All of the susceptible varieties

were red russets, while the color of the resistant ones in the main was white or rose. The eating qualities of the latter as a class were quite inferior.

Jones (12) in 1903, then located at the Vermont station, considered certain German (Richter's Imperator, Prof. Wohltmann, Irene), and American varieties (White Beauty, Carmen No. 3, American Giant, Sir Walter Raleigh, Irish Cobbler, Scab Proof, Aurora) to be somewhat scab resistant.

The most extensive observations on scab resistance were made by Stuart (19) at the Vermont station during 1906 and 1907, using 74 varieties. During both seasons the German variety Boncza—like Abou Ben Adhem—"led all the rest"; Million Dollar (American) ranked second in 1906 and sixth in 1907; Sir John Llewellyn (English) sixth and third; Ninety-fold (English) tenth and second; Fuerst Bismark (German) third and fourth.

Stuart states:

"1. That none of the varieties tested showed strongly marked scab resistant qualities when grown on soil well infested with scab organisms.

2. That the notion commonly prevalent to the effect that a russet skinned variety does not become scabby is not based on fact, as evidenced by the behavior of Cambridge Russet which occupied fourteenth position in 1906 and eighteenth in 1907. Personal observation during the past six years corroborates this statement.

3. That some varieties are apparently somewhat less subject to scab than are others (Boncza and others); but whether this immunity is wholly or only partially inherent cannot be determined from the data now in hand.

4. That there seems to be little hope of securing scab resistant varieties through selection."

The observations made thus far seem to agree on only a single point, namely, that some varieties of potatoes are more resistant than others. The current belief that red or dark skinned types resist scab better than the lighter colored ones does not seem to be sustained by the data then available. Doubt is cast also on the notion that the thicker skinned varieties are necessarily more resistant than those with thinner skins. In fact, these observations only permit us to recognize the resistance of some varieties without affording definite clue as to the underlying cause which induces resistance.

1914 TRIALS

The scab resistance experiments reported in this article were begun in 1914 at the Vermont station and continued for four years. The land was a very light sandy loam, known to be badly infected with the scab organism, more on the east portion than upon the west, a fact which should be kept in mind in drawing conclusions as to comparative results. All trials were often repeated in order, as nearly as possible, to equalize the conditions of the two sides of the plot. The land had been in hay during 1913 and it had received a somewhat heavy application of stable manure as a topdressing, which was repeated during the winter and spring as a precedent to the 1914 crop.

Most of the seed was obtained through the courtesy of Prof. Wm. Stuart of the Federal Department of Agriculture, formerly horticulturist of this Station, who furnished some 20 varieties, and of Prof. C. A. Zavitz of the Ontario Agricultural College. The American varieties were planted during late May and the Canadian ones on their arrival on June 18. In addition to these, Cowhorn, a peculiar dark purple, thick skinned sort that is grown to some extent in the mountain regions of Vermont, was planted. Each variety was set in a short row of about 25 plants, on both the east and the west portions of the plot. The seed was practically free from external indications of scab and, in a few cases, was disinfected with formaldehyde in order to insure the destruction of any possible sources of infection. Every tuber, both large and small, was individually examined and recorded, the many small tubers accounting for the apparently unusual numbers recorded as compared with the total weight.

The results appear in the following table:

TABLE I—SCAB RESISTANCE OF POTATO VARIETIES, 1914

(Arranged in order of freedom from scab)

Variety	Weight of tubers	Number of clean tubers	Number of slightly scabby tubers*	Number of badly scabby tubers	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
	lbs.				%	%	%
Cambridge Russet.....	38	264	46	0	85.2	14.8	0
Scab Proof	31.7	238	54	0	81.5	18.5	0
Cowhorn	57.5	313	173	16	62.3	34.5	3.2
Burbank's Russet	53.7	285	213	1	57.1	42.7	0.2
Dakota Red	64.2	203	208	6	48.7	49.8	1.5
Million Dollar	45	131	195	8	39.2	58.4	2.4
White Ohio	71	203	295	45	37.4	54.3	8.3
Dibble's Russet	63.6	132	225	3	36.6	62.4	1
Rural New Yorker No. 2	67.8	119	324	4	26.6	72.5	0.9
Beauty of Hebron	93.7	286	487	48	25.8	67.6	6.6
Irish Cobbler	64.5	114	263	146	21.8	50.3	27.9
Early Rose	61.8	111	345	100	19.9	62.1	18
Twentieth Century	47.2	48	258	55	13.3	71.5	15.2
Pride of Vermont	50	41	262	60	11.3	72.2	16.5
Vermont Gold Coin....	51.5	61	392	101	11	70.8	18.2
Moroton Beauty	8.7	12	102	8	9.9	83.6	6.5
Extra Early Eureka...	18.5	12	111	13	8.8	81.6	9.6
Bovee	65.1	39	546	118	5.5	77.7	16.8
Early Ohio	51	12	314	16	3.5	91.8	4.7
Triumph	29.5	10	320	60	2.5	82.1	15.4
Norcross	69.3	18	309	254	3.1	53.2	43.7
White Star	67.4	16	293	309	2.6	47.4	50
Average					27.9	59.9	12.2

*Less than 5 percent of surface; not more than one or two large scabs on a fair sized tuber; not enough materially to injure the tuber for sale or seed.

It is clear that at the head of the resistant class stand the potatoes of the russet type. It should be noted that Scab Proof is one of the thickest skinned of these russets. Cowhorn and Dakota Red (a red skinned variety) yielded practically as high a percentage of clean tubers. The susceptible varieties are, in the main, white skinned, although Triumph is pink skinned. The thickness of the skin seemed to have more to do with the quality of resistance than the color.

A comparison of yields from scabby and clean tubers was made in certain trials conducted on the land immediately east of that on which the varieties were tested. The soil was as much inclined to produce scabbiness as any that could be found. Green Mountain tubers, both clean and scabby, were used. The clean seed were not disinfected but betrayed no trace of scab. The scabby seed were at

least half covered by disease. Alternate rows were planted, three scabby and three clean. The slightly scabby tubers were counted as in the preceding experiment. The results were as follows:

	Number of hills	Clean tubers	Slightly scabby tubers	Badly scabby tubers	Weight of large tubers	Weight of small tubers	Total weight of tubers	Weight per plant
					lbs.	lbs.	lbs.	lbs.
Clean	108	0	259	844	93.3	42.3	135.6	1.25
Scabby	121	0	376	928	104.1	51.2	155.3	1.28

No clean tubers were produced and there were as many badly scabbed in the one case as in the other. The difference in yields of slightly scabby tubers, however, is a little in favor of the scabby seed. This result is hardly to be expected for the reason that the planting of tubers as badly affected by the disease as were those used for seed, gave as much chance for infection as would the placing of a heavy inoculation or a spadeful of manure at the exact place in which the young tubers are to be formed.

The almost absolute identity of the individual plant yields from clean and from scabby seed is interesting in view of the claims to the contrary made by Goff (7) and Bolly (2) to the effect that extreme scabbiness of seed tends to lessen the crop. In this trial, at any rate, the scabby seed produced as largely as did the clean seed.

1915 TRIALS

The same land was used in 1915 and the same seed—with minor exceptions—was grown in the same soil. The large percentage of scab infection made disinfection necessary, hence all varieties were soaked for two hours in formaldehyde solution. The results follow:

TABLE II—SCAB RESISTANCE OF POTATO VARIETIES, 1915

Variety	Yield per hill	Number of clean tubers	Number of slightly scabby tubers	Number of badly scabby tubers	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
	lbs.				%	%	%
Scab Proof	2.11	691	10	0	98	2	0
Cambridge Russet	1.85	575	18	0	97	3	0
Burbank's Russet	2.5	600	66	20	87.4	9.6	2
Cowhorn	3.01	131	403	193	18	55.4	26.6
White Ohio	1.6	91	304	91	18.7	63.6	18.7
Early Ohio	1.5	68	362	47	14.2	75.9	9.9
Early Rose	1.94	100	508	110	13.9	70.7	15.4
Beauty of Hebron	2.73	117	476	275	13.5	54.8	31.7
Triumph	1.03	51	311	57	12.2	74.2	13.6
Million Dollar	2.21	47	307	81	10.8	70.6	18.6
Dibble's Russet	2.51	42	367	101	8.2	72	19.8
Irish Cobbler	1.97	59	580	98	7.9	75.5	16.6
Dakota Red	2.72	47	358	233	7.3	56.2	36.5
Bovee	2.08	54	387	268	7.6	54.4	38.0
White Star	3.04	56	450	365	6.4	51.6	42.0
Rural New Yorker No. 2	2.82	28	443	127	4.7	74.0	21.3
Davies' Warrior	1.04	21	264	239	4.0	50.3	45.7
Vermont Gold Coin	2.01	32	311	382	4.4	42.8	52.8
Pride of Vermont	2.38	21	337	387	2.8	45.2	52.0
Green Mountain	3	11	538	255	1.3	66.9	31.8
Norcross	2.61	2	209	626	0.2	24.9	74.9
Average					20.9	52.1	27

The russet varieties, as in the preceding year, stand at the top of the list for disease resistance, whereas Cowhorn and Dakota Red seem to some extent to have lost their preeminence and to have dropped into the middle class.

1916 TRIALS

The same land was again used in 1916, commercial potato fertilizer being used in the furrows before planting. All seed was disinfected. Professor Stuart furnished several seedlings originated in the Federal Department for testing as to disease resistance. These are indicated by his numbers. Three English varieties, Ninety-fold, Sir John Llewellyn and Reading Russet were bought from Sutton & Sons of Reading, Eng., but arrived in such poor condition that only a few of them could be planted. The low yields from the first two may be explained by the fact that they were only planted once in the field and not repeated as were the other varieties.

TABLE III—SCAB RESISTANCE OF POTATO VARIETIES, 1916

Variety	Weight of tubers	Number of clean tubers	Number of slightly scabby tubers	Number of badly scabby tubers	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
	lbs.				%	%	%
Scab Proof	16.0	36	42	21	36.3	42.4	21.3
Burbank's Russet	21.8	87	49	78	40.6	22.9	36.5
Cambridge Russet	14.5	56	79	23	35.5	50.0	14.5
1665	70.3	17	91	537	2.6	14.1	83.3
4227	72.8	46	164	745	4.8	17.2	78.0
3766	44.8	11	113	558	1.6	16.6	81.8
1212	67.2	64	95	883	6.1	9.1	84.8
15284	38.8	0	68	363	0	15.8	84.2
13660	70	0	92	494	0	15.7	84.3
17087	56	4	78	595	0.6	11.5	87.9
3760	59.8	6	82	544	1	12.9	86.1
Ninety-fold	6.5	1	14	67	1.2	17.1	81.7
Sir J. Llewellyn	14.5	5	27	192	2.2	12.0	85.8
17365	73.2	0	58	573	0	9.2	90.8
13222	55.3	3	32	350	0.8	8.3	90.9
7322	43	0	40	435	0	8.4	91.6
11844	30.8	3	18	227	1.3	7.2	91.5
3073	61.2	11	37	545	1.8	6.2	92.0
22245	32.5	0	31	329	0	8.6	91.4
21781	28.8	0	35	397	0	8.1	91.9
22725	30.7	0	31	331	0	8.6	91.4
22723	34.5	0	32	447	0	6.7	93.3
22597	26	0	15	225	0	6.3	93.7
2590	45.8	1	30	656	0.1	4.4	95.5
1147	32.3	5	18	416	1.1	4.1	94.8
4755	32.3	7	13	385	1.7	3.2	95.1
5727	57.5	0	36	676	0	5.1	94.9
7192	30.5	0	12	276	0	4.2	95.8
14329	73.8	0	45	885	0	4.9	95.1
Davies' Warrior	17.5	0	12	172	0	6.6	93.4
Cowhorn	23.5	5	9	169	2.9	4.9	92.2
Rural New Yorker No. 2	17.3	0	8	128	0	5.9	94.1
Dibble's Russett	23	0	8	162	0	4.7	95.3
7735	29	0	9	295	0	3	97
4240	56.3	0	17	558	0	3	97
225	41.8	0	8	547	0	1.4	98.6
23083	21.8	0	4	298	0	1.3	98.7
White Star	11.5	0	3	142	0	2	98
Beauty of Hebron	14.3	0	6	178	0	3.2	96.8
Vermont Gold Coin	15.2	0	2	158	0	1.25	98.75
Million Dollar	30.5	0	5	219	0	2.2	97.8
Bovee	27.8	0	1	233	0	0.43	99.7
Early Rose	12.0	1	4	167	0.6	2.3	97.1
Norcross	20.5	0	1	179	0	0.6	99.4
Reading Russet	30	0	5	222	0	2.2	97.8
Green Mountain	30.8	0	2	240	0	0.8	99.2
Irish Cobbler	17.3	0	0	199	0	0	100
Pride of Vermont	4.5	0	0	45	0	0	100
Dakota Red	30.5	0	0	260	0	0	100
Early Ohio	13.3	0	0	175	0	0	100
Triumph	16	0	0	213	0	0	100
White Ohio	13.5	0	0	145	0	0	100
Average of varieties (19) used in 1914 and 1915					5.3	6.9	87.9

The conspicuous feature of the results from the 1916 harvest is the enormous increase in the amount of scabbiness. While 27.9 percent of the tubers were clean in 1914 and 20.5 percent in 1915, only 5.3 percent were free from scab in 1916, confining the comparison to those varieties grown each year. On the other hand, the number of badly scabbed tubers had increased from 12.2 percent in 1914 to 28 percent in 1915 and to 87.9 percent in 1916. It will be noticed that nearly half the large number of varieties grown were affected by scab to an extent in excess of 95 percent. It should be noted in this connection that no manure whatever had been applied to the land since 1914, commercial fertilizer alone being employed, yet the parasitic strains of Actinomyces increased in this soil, notwithstanding the comparative lack of humus. Clearly these soil organisms do not readily succumb. Several investigators have noted similar increases in scabbiness on soils repeatedly planted to potatoes. Clinton says: "The first year the potatoes were on the land the percent of scab was so small that it was not determined. It certainly was below five percent and probably not over one percent. The second year, 1907, scabby tubers had increased to 22 percent, in 1908 to 47 percent (the same potatoes on our general rotation field this year gave only about one percent scabby), and in 1909 to 63 percent. The last two years the scab was so bad as to seriously affect the market value of the potatoes."

Tests were made of the so-called soil acidity of the experimental plot, samples being taken in various parts. It was estimated that its lime requirement was equivalent to 2,500 pounds calcium oxid per acre. The general notion that an alkaline soil reaction necessarily induces scab attacks was not upheld in the present instances.

Scab infestation had become so excessive on this plot that there seemed little likelihood that comparable results could be secured in the future and the trials were transferred in 1917 to a new location.

1917 TRIALS

The seed were planted in 1917 on land that had been in grass for eight years, on which during many years previous an orchard had existed. The stumps of some of the old apple trees were still in sight Nothing was known as to its past history in relation to scab. Each variety was planted in two different locations in the field in order somewhat to compensate for variations in scab infestation. The fate of the crop was a hard one. The land had not been properly plowed and no

commercial fertilizer was used. The plants succumbed early in the season to tip burn, which was undoubtedly aggravated by a lack of available potash and, to make a bad matter worse, mosaic developed on at least half the varieties. The yields of some varieties was practically nil. The results appear in the following table, stated in the order in which the varieties were planted in the field.

TABLE IV—SCAB RESISTANCE OF POTATO VARIETIES, 1917

Row	Variety	Total number of tubers examined	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
			%	%	%
1	Cambridge Russet	237	36.2	62.8	1
2	Dibble's Russet	480	21	72.5	6.5
3	Dibble's Russet (disinfected)	278	24.8	70.8	4.4
4	4240 (disinfected)	611	21.2	75.6	3.2
5	Early Rose (disinfected)	415	21.7	72.5	5.8
6	Early Rose	322	13.3	78.2	8.5
7	22083 (disinfected)	250	0.8	90	9.2
8	Green Mountain (disinfected)	286	14.3	78.6	7.1
9	Green Mountain	299	6.8	77.2	16
10	Cowhorn	30	60	40	0
11	Burbank's Russet	66	57.5	41	1.5
12	Ninety-fold (disinfected)	122	0.7	87	12.3
13	Reading Russet (disinfected)	210	1	89.5	9.5
14	5727	513	4.7	84.2	11.1
15	5727 (disinfected)	665	8.8	81.9	9.3
16	Bovee (disinfected)	513	7.4	86.5	6.1
17	Bovee	577	4.3	79.7	16
18	1665 (disinfected)	470	3.6	93.8	2.6
19	4227	481	4.5	91.5	4
20	4227 culls (disinfected)	369	3	88.6	8.4
21	3073 (disinfected)	477	1.2	94.1	4.7
22	Sir John Llewellyn (disinfected)	418	19.6	80.4	0
23	3766 (disinfected)	400	0.8	91	8.2
24	Bovee (disinfected)	578	25.7	74	0.3
25	Bovee	535	11	80.7	8.3
26	Scab Proof	327	62.1	37.9	0
27	Green Mountain (disinfected)	344	1.1	92.4	6.5
28	Green Mountain	417	7	84.9	8.1
29	Green Mountain (disinfected)	393	10.1	81.1	8.8
30	Green Mountain	278	5	85.3	9.7
31	Scab Proof	191	39.8	56.5	3.7

TABLE V—POTATO VARIETIES, 1917, ARRANGED IN THE ORDER OF THEIR RESISTANCE TO SCAB

Variety	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
	%	%	%
Cowhorn	60	40	0
Burbank's Russet	57.5	41	1.5
Scab Proof	55.9	47.2	1.8
Cambridge Russet	36.2	62.8	1
Dibble's Russet	22.9	71.6	5.4
4240	21.2	75.6	3.2
Sir John Llewellyn	19.6	80.4	0
Early Rose	17.5	75.3	7.1
Bovee	12.1	80.2	7.6
Green Mountain	7.4	83.2	9.2
5727	6.7	83	10.2
4227	3.7	90	6.2
3073	1.2	94.1	4.7
Reading Russet	1	89.5	9.5
22083	0.8	90	9.2
3766	0.8	91	8.2
Ninety-fold	0.7	87	12.3

The results of disinfection with formaldehyde may be summarized as follows:

TABLE VI—EFFECT OF DISINFECTION ON AMOUNT OF SCAB, 1917

Varieties	Clean tuber *not* disinfected	Disinfected	Slightly scabbed tubers *not* disinfected	Disinfected	Badly scabbed tubers *not* disinfected	Disinfected
	%	%	%	%	%	%
Dibble's Russet ..	21	24.8	72.5	70.8	6.5	4.4
Early Rose	13.3	21.7	78.2	72.5	8.5	5.8
Green Mountain..	6.8	14.3	77.2	78.6	16	7.1
5727	4.7	8.8	84.2	81.9	11.1	9.3
Bovee	4.3	7.4	79.2	86.5	16	6.1
4227	4.5	3	91.5	88.6	4.0	8.4
Bovee	11	25.7	80.7	74	8.3	0.3
Green Mountain..	7	1.1	84.9	92.4	8.1	6.5
Green Mountain..	5	10.1	85.3	81.1	9.7	8.8
Average of above six varieties ...	8.6	13	81.5	80.6	9.8	6.4

In nearly all cases where the seed was treated a slight increase occurred in the percentage of clean tubers and a slight diminution in that of badly scabbed tubers.

The 1917 results confirm those of the preceding years. The russet types stand at the head of the list for scab resistance but have asso-

ciated with them the variety Cowhorn. Dibble's Russet, 4240 and Sir John Llewellyn occupy a middle position on the scale of resistance, while the other varieties follow with varying percentages. The small percentage badly scabbed as compared with 1916 shows that the transfer to new land had brought a marked improvement and that the heavy percentage of scabbing in 1916 was due to the land and not to the season. Seasonal data on scabbing must be accepted with caution for the reason that it is common to change the location of the planting yearly in order to lessen scab ravages, a practice which makes it difficult to institute accurate comparisons.

GENERAL CONCLUSIONS.

1. Repeated planting of potatoes on the same soil increases the percentage of scab even if no manure or lime is added to the soil.

2. Marked resistance to scab is found in the true russet types of tubers. The semi-russets show some scab resistance while the white, thin skinned varieties seem to be most susceptible.

THE RELATION OF THE THICKNESS OF THE SKIN OF POTATO TUBERS TO THEIR RESISTANCE TO SCAB

The results of the field trials at the Vermont station have led to the conclusions that the thickness of the skin of the tubers has much to do with their resistance to scab. The russet skinned types, with their very thick, corky skin layers, seemed to stand in a class by themselves in respect to their ability to withstand the inroads of disease.

Small pieces of tuber skins representing several varieties were fixed in Flemming's weaker mixture, imbedded in paraffin, cut and stained. It was then (1915) thought that the determination of the number of cell layers was all that would be necessary and no attention was given to the actual thickness of the samples. Furthermore, an unforeseen difficulty was encountered in that the skin of a single tuber varied profoundly in one spot as compared with another. Few American varieties exhibit entirely smooth surfaces, a careful examination revealing scales where the cork layers are very thick and, often, thinner portions where the protective layers seem to be much fewer in number. It is easy to see that the difficulties of representative sample taking under the circumstances are extremely great and that much opportunity is offered for personal bias in the matter of selection. The writer was unable to devise any method that would eliminate this

personal equation but he attempted to be as fair as possible in sample taking. Potato tubers with diameters lying between one and six centimeters were used for the section in these earlier trials. Scab infections, especially the deeper ones, must occur when the tuber is only partly grown and the protective layer that covers it at that time must be the one which will prevent—if it prevents at all—the entrance of the parasite. At least 30 counts were made from five or more slides in each instance.

The writer wishes to acknowledge the help of Mr. H. E. Bartram, formerly assistant plant pathologist, in the work of making the sections and counts on the varieties and on a part of those made after different soil treatments.

TABLE VII—NUMBER OF CORK LAYERS ON GROWING TUBERS

						Cell layers
Dibble's Russet,	tubers	about	2	cm.	diameter.....	8.9
White Star,	"	"	2	"	"	8.7
Burbank's Russet,	"	"	3	"	"	11.5
Rural New Yorker No. 2,	"	"	6	"	"	8.7
Irish Cobbler,	"	"	6	"	"	8.8
Scab Proof,	"	"	7	"	"	8.7
Scab Proof,	"	"	3	"	"	12.3
Dakota Red,	"	"	1	"	"	7
Dakota Red,	"	"	2	"	"	8.5
Triumph,	"	"	3	"	"	8.9
Early Ohio,	"	"	½	"	"	7.8
Cambridge Russet,	"	"	1	"	"	7.6
Cambridge Russet,	"	"	1	"	"	7.6
Cambridge Russet,	"	"	2	"	"	8.5
Green Mountain,	"	"	2½	"	"	6.7
Beauty of Hebron,	"	"	3	"	"	7.1
Cowhorn,	"	"	2	"	"	7.9
Bovee,	"	"	2	"	"	8.1

It is doubtful whether these determinations mean very much: yet the fact cannot be gainsaid that very susceptible varieties, such as Green Mountain, Early Ohio, Beauty of Hebron and Bovee, are among the very thin skinned varieties, whereas Burbanks' Russet and Scab Proof possess much thicker cork layers. The majority of the varieties tried, however, lie midway between the two extremes as they do in their resistance to scab in the field. Exceptions to this are to be noted in Cowhorn and Cambridge Russet, both fairly resistant varieties, which do not seem to possess an unusual number of cork layers. It is entirely possible that the number of layers of cork in these two instances continue to increase as the tubers grow older, while in the other varieties the maximum is attained earlier. It will be noticed in this con-

nection that the cork layers on Scab Proof increase in thickness from 8.7 layers when the tubers are one centimeter in diameter to 12.3 layers when they are six centimeters in diameters; and it should be noted in that connection that the russet appearance develops while the tubers are thus growing, a fact which may well account for the additional layers.

Further data were desired as to more mature tubers; hence a series of sections was cut from potatoes grown in 1917 on another plot. The potato pieces were cut on a freezing microtome, as will be described in detail later. No attempt was made to secure average samples. The measurements were made of thick and thin spots, if such were present, and the records kept separately. No attempt was made by calculation to arrive at the probable average thickness of the skin for the tuber as a whole.

TABLE VIII—THICKNESS OF CORK LAYERS ON MATURE TUBERS

Variety	Thick portion cell layers	Thin portion cell layers	Thick portion microns	Thin portion microns
Early Rose	14	9.7	120	95.9
Reading Russet	....	12.5	....	111.5
Bovee	none	7.8	none	97
Sir John Llewellyn	....	8.4	....	96.3
Burbank's Russet	12.7	7	182.2	87.5
Irish Cobbler	9.8	7.6	116.6	86.6
Cowhorn	....	12.6	....	138.6
Dibble's Russet	10.9	6.7	137	100
Green Mountain	9.5	6.6	110	89.2

The measurements taken from the sections corroborate the external appearance of the tubers. Green Mountain, Early Rose and Irish Cobbler exhibit scales or scurf, but these scales are not nearly as pronounced on Dibble's Russet and the measurements of the thick portions (in microns) show that they are not as thick. Reading Russet seemed to have no thin places in its cork layers, the skin being uniform and fairly thick. The same may be said of Cowhorn. Burbank's Russet does not exhibit an unusual number of cork layers in its thin portions, but the russetted areas have a high number of cells which form a thick layer.

The thick and thin portions alternate with considerable regularity in sections of Scab Proof, so it was possible to measure their width on a series of sections. A series of the russetted portions measured in width 1520 square microns in cross section and the width of the thinner parts between them was 6456 square microns. The area covered by

the two types of surface of the skin of the tuber would be represented by the square of the above figures, *i. e.*, by the proportion of 2,310,400 to 41,679,936. This is equivalent to saying that over twenty times as much of the entire skin area is covered by the russetted areas as is covered by the thinner portions.

Surface views of the skins of a number of varieties of tubers are shown on plates I and II. Figures 1-2, inclusive, are natural size while figures 7-14, inclusive are magnified about six diameters. The latter figures were taken with a Micro-Tessar lens and long bellows camera.

The net-like appearance of the skin of the russet types is shown by figure 1 of Scab Proof and figure 2 of Cambridge Russet. The above calculation as to the extent of the russetted area is substantiated by the magnified view of the outside of the tuber. The thinner scales, such as occur on most American varieties, are seen in figure 3 of Cowhorn, figure 4 of Rural New Yorker No. 2 and figure 5 of Dibble's Russet. These scales are large on the skin of Cowhorn, while on most varieties they are much smaller. Cracks often develop in the outer corky layer on Cowhorn.

The russetting on the Irish Cobbler potatoes in figure 6 is believed to be due to the stimulus of fertilizers. It is the common belief among growers that heavy applications of commercial fertilizer have a tendency to russet the tubers. The tubers shown exhibited the russetting on the side on which there was a thick deposit of sulphur.

The thick russet layer on Scab Proof and Burbank's Russet is even more clearly shown in figures 11 and 13 in which the surface is magnified about six diameters. The lenticels on these varieties can be seen as white spots above the x on either figure. The ease with which the lenticels can be seen on the skin of these varieties has been exaggerated since they are usually so deeply imbedded in the thick cork layers that it is difficult to distinguish them from a scale. In fact it is almost impossible to see them on a dry potato and hence these tubers were kept moist for an hour or two before the photograph was taken in order to swell the lenticels so that they would show.

The skin of Cowhorn (figure 7) when magnified looks very much like morocco leather. The clefts in the thick corky layers are comparatively small in area as compared to the thicker portions. The granular structure seems to be due to the large pigmented cells which lie under the corky layer and give to the tuber its dark purple color.

Green Mountain (figure 8) and Dakota Red (figure 9) have

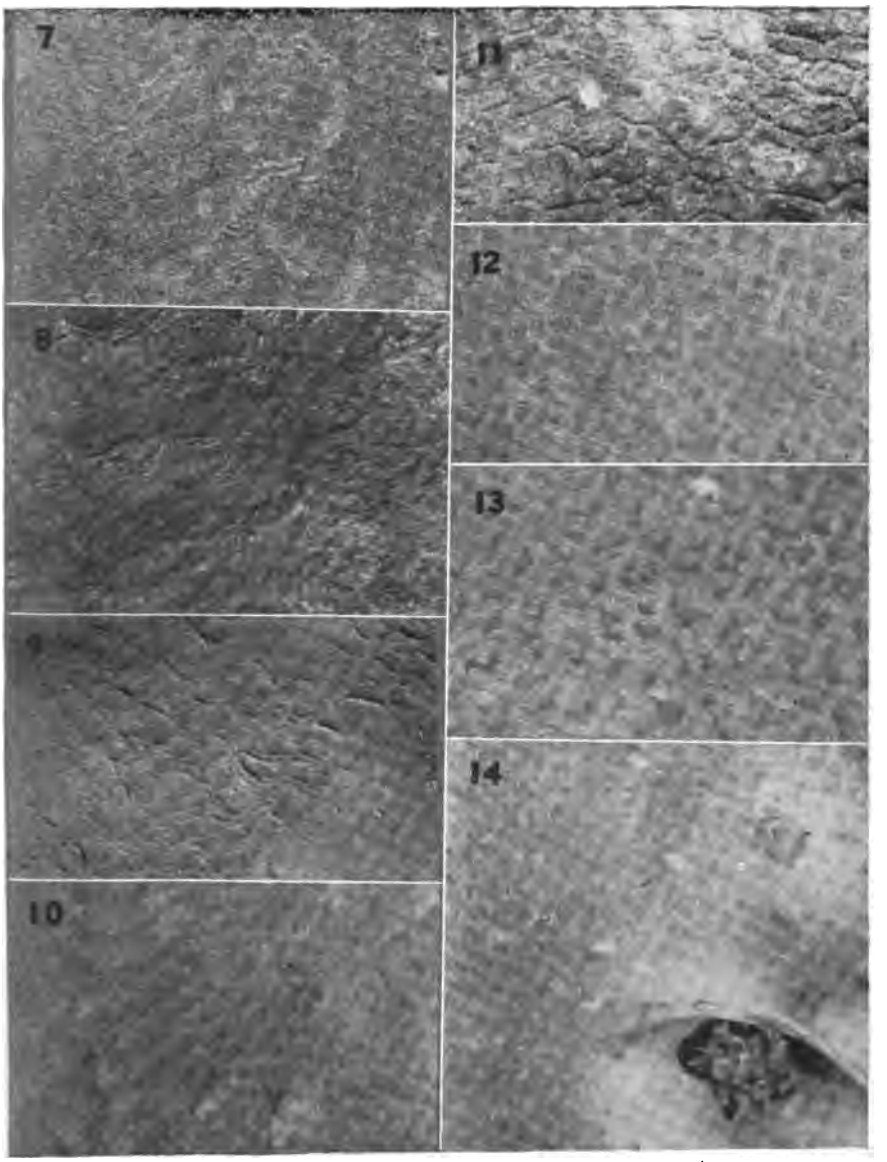

PLATE II.—Figure 7. Skin of Cowhorn × 6. Figure 8. Skin of Green Mountain × 6. Figure 9. Skin of Dakota Red × 6. Figure 10. Skin of Bovee × 6. Figure 11. Skin of Scab Proof × 6 Figure 12. Skin of Rural New Yorker No. 2 × 6. Figure 13. Skin of Burbank's Russet × 6. Figure 14. Skin of Early Rose × 6.

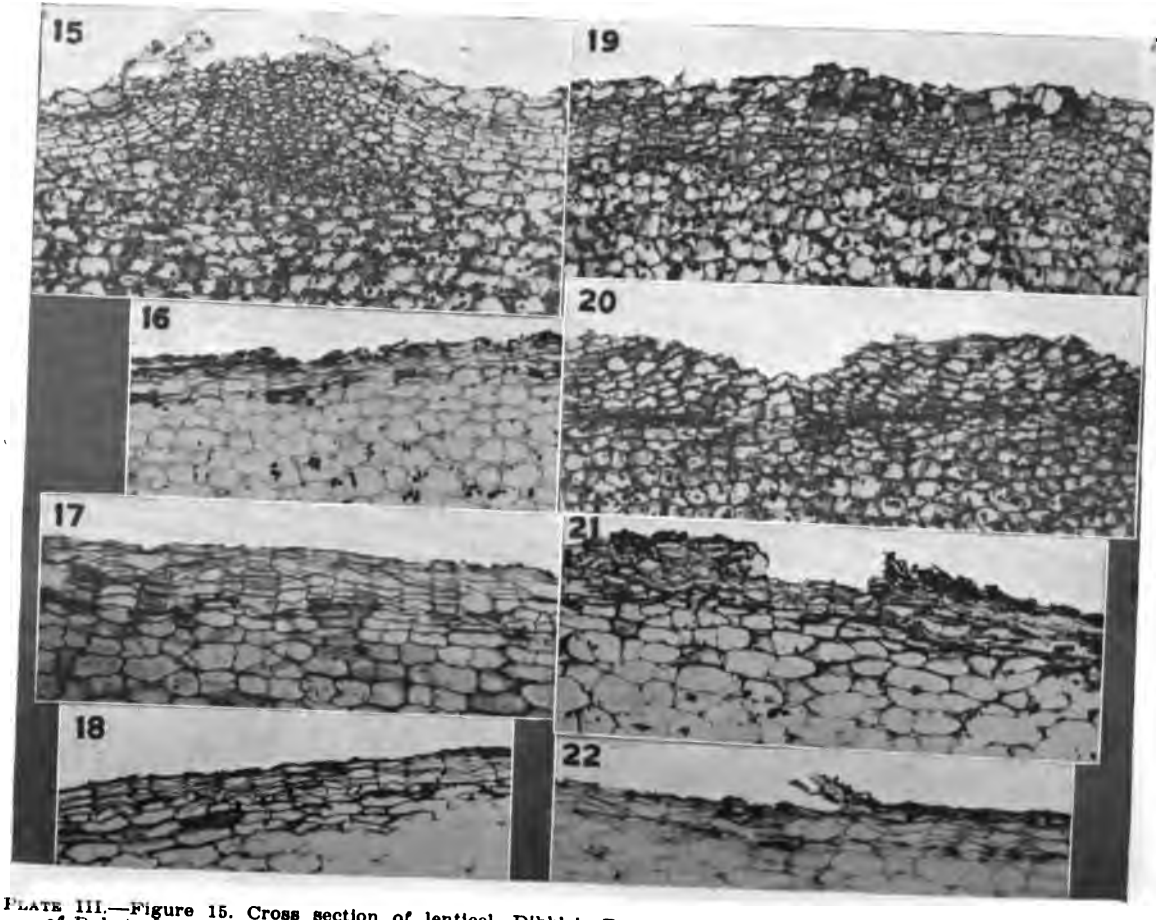

PLATE III.—Figure 15. Cross section of lenticel, Dibble's Russet × 90. Figure 16. Cross section of skin of Dakota Red × 90. Figure 17. Cross section of skin of Cowhorn × 90. Figure 18. Cross section of skin of Irish Cobbler × 90. Figure 19. Cross section of skin of Scab Proof, before surface markings appear × 90. Figure 20. Cross section of skin of Scab Proof, after surface markings appear × 90. Figure 21. Cross section of skin of Scab Proof, old tuber from storage × 90. Figure 22. Cross section of skin of Dibble's Russet × 90.

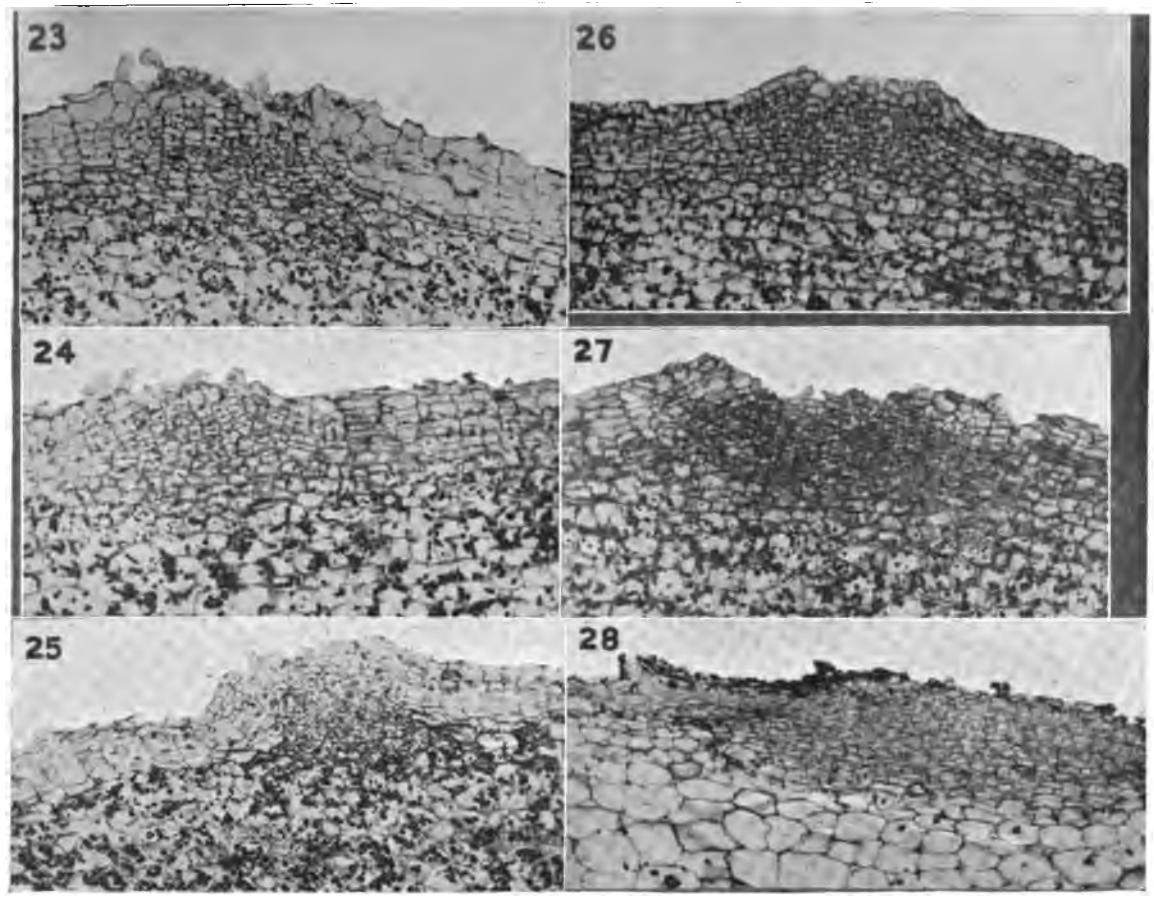

PLATE IV.—Figure 23. Cross section of lenticel of Green Mountain × 90. Figure 24. Cross section of lenticels of Dakota Red × 90. Figure 25. Cross section of lenticel of Bovee × 90. Figure 26. Cross section of lenticel of Scab Proof from a small tuber × 90. Figure 27. Cross sction of lenticel from an old mature tuber × 90. Figure 28. Cross section of a lenticel of Burbank's Russet × 90.

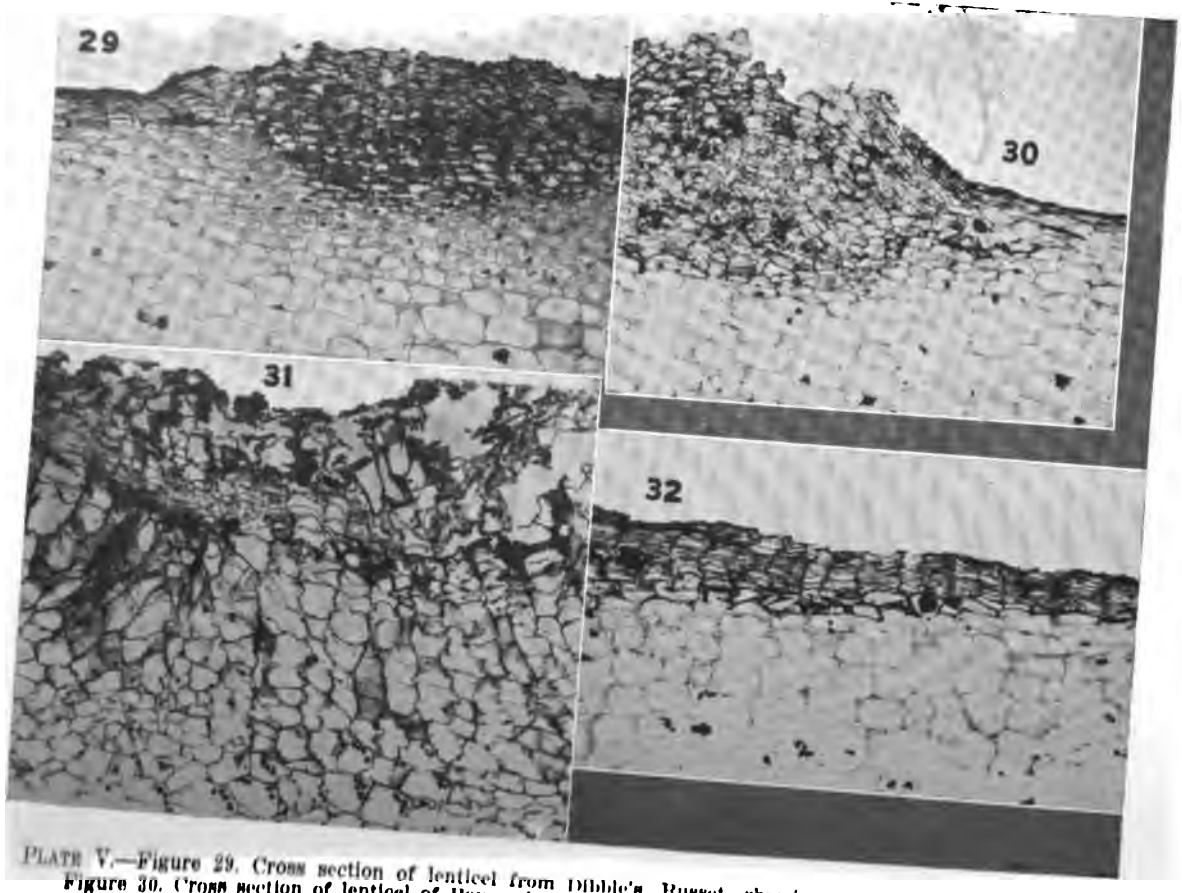

PLATE V.—**Figure 29.** Cross section of lenticel from Dibble's Russet showing early scab lesion × 90. **Figure 30.** Cross section of lenticel of Bovee showing early scab × 90. **Figure 31.** Cross section of scab lesion on Irish Cobbler showing the effect of the scab organism on the storage tissue × 90. Figure 32. Cross section of scab lesion on Early Ohio × 90 hypertrophied cells with suberized walls showing under the cork layers, no evidence of the proximity of a lenticel through which infection may have occurred

comparatively smooth surfaces but clefts occur in them, which in some cases cause them to assume somewhat of a russet appearance. Bovee (figure 10) and Early Rose (figure 14) both grow smooth surfaced tubers but even in these varieties both thicker and thinner skin regions seem to occur. The large size and prominence above the surface of the lenticels of these two tubers is very marked. They protrude above the surface and invite infection, while on the russet types the lenticels lie imbedded in a mass of corky tissue.

The sections confirm the surface indications and disclose certain facts as to structure of the skin textures that are of interest. Dakota Red (figure 16), Cowhorn (figure 17), Irish Cobbler (figure 18) and Dibble's Russet (figure 22) are comparatively smooth varieties and the sections show no marked differences in one as compared with the other. Cowhorn has a few more layers of cork and Dibble's Russet shows a section of one of the thin scales which cover the tuber. The cork cells of Cowhorn, however, exhibit one peculiarity, which, while it shows in the reproduction, is still more clearly observed in the sections. The cork cells of most varieties become crushed down against the tuber proper and their walls are crumpled and irregular. In Cowhorn, however, the walls of these cells seem to be of a firmer nature and the cells retain their rectangular shape in section. They are easily counted in sections, whereas it is almost impossible to distinguish the number of layers in tubers like those represented by figure 22, where the cell walls lie crushed one against the other.

The development of the russet areas on potatoes of this type is shown in figures 19-21. The very small tubers are, of course, smooth and not yet russetted. Figure 19 was taken from sections of such very young tubers. The cork layer at this time is thick and the cells are full and plump, but no thick or thin places have as yet developed. The material from which figure 20 was taken was fixed immediately after the tuber was taken from the soil and the cells stand out with turgid walls. The number of cells in the cork cambium region is sometimes difficult to count accurately. An old tuber taken from the storage bin was used for the section for figure 21 and the cork cells have been so crushed that it is almost impossible to count them.

Thickness of skin, while it is probably important, may not be the only factor involved in resistance or susceptibility to scab. As the writer has shown in a previous paper (16) and as had been still earlier pointed out by Frank (6), lenticels are the usual place of en-

trance for the scab organism. Probably all very deep scabs originate from the lenticels; hence their structure and position in the several varieties assume an importance certainly as great as if not greater than the structure of the skin itself. Sections of lenticels on growing tubers with a diameter of 1-6 centimeters are shown in figure 15 of Dibble's Russet, figure 23 of Green Mountain, figure 24 of Dakota Red, figure 25 of Bovee, all of which are susceptible to or only moderately resistant to scab. The protrusions of these structures above the level of the tuber is pronounced in several of these figures. The other character which is more easily made out in the sections than in these figures is the somewhat loose construction of the lenticels itself. The cells are rather large and do not seem to differ much from those of the cork cambium. The nuclei are large and the cells give every indication of being active and capable of continued division. The introduction of the scab organism here may easily divert them to the abnormal, cork formation of the type described by the writer as typical of scab tissue.

In contrast to the structure of the lenticels of these more susceptible varities should be set forth the lenticels of Scab Proof and Burbank's Russet, both of which are very susceptible. That of the very young Scab Proof (figure 26) would seem to be hardly distinguishable from the lenticels of susceptible types. Its cells are possibly a little rounded in section and not as rectangular. An old lenticel from a tuber well russetted is likely to lie below the level of the surface due to the continued growth of the cork to form the thick portions of the skin. The large lenticel in Burbank's Russet (figure 28) is partly covered by the thick russet scale at its left margin. The depth to which the lenticel tissue extends into the tuber should be noted as well as the very small size of the cells, their roundness, and the generally close structure of the tissue. Penetration by hyphae would seem to be more difficult than in the lenticels exhibited in figures 15, 23, 24 and 25.

The early stages of infection with the scab Actinomyces has been discussed at some length by the writer in another paper (16) but figures 29-32, inclusive, bring out some points that are of interest. Figure 29 shows the lenticel filled with cork cells with abnormally thick walls which stain very densely. The cork cambium layer at the bottom of the scab is not distinct. Part of the cells in the other lenticel (figure 30) from Bovee are fairly normal, while others are hypertrophied and exhibit very thick walls. The cork cambium layer is

still fairly distinct at the base of the lenticel tissue. Figure 30 (Irish Cobbler) is of interest because the storage tissue has become involved in the scab. The writer (16) has claimed that scab tissue is largely of the cork or cork-like type and derived from the outward growth of cells from the cork cambium. In this section, however, which is apparently of a shallow scab and possibly not from a lenticel, the growing layer seems to be throwing off abnormal cork cells peripherally and also internally giving rise to large, hypertrophied, empty parenchyma cells.

The formation of abnormal cells of the scab type beneath the cork layers is shown in figure 32. The stimulus of the Actinomyces may not have induced this condition in these cells but as scab was fairly common on all these tubers it is only fair to assume that it did. The corky covering of the potato is probably not without breaks through which the hyphal threads might grow and it is possible too that the excretion products of the organisms might be absorbed through the corky layer if the superficial growth was abundant.

EFFECT OF CHEMICALS ON AMOUNT OF SCAB

The ends of the varietal rows were utilized for tests of the effect of the application of sundry chemicals upon the amount of scab. The chemicals were scattered by hand in the furrows and then covered with soil. It was impossible to judge accurately as to the amount used, but apparently from 300 to 500 pounds per acre were employed. Germination was uninjured so far as observed. Clean Green Mountain tubers were used. Each of the various chemicals were tried at six different places on the plot and the results ought to be fairly indicative of the facts.

TABLE IX—EFFECT OF CHEMICALS ON SCAB

Treatment	Number of plants	Number of clean tubers	Number of slightly scabby tubers	Number of badly scabby tubers	Total number of tubers	Clean tubers	Slightly scabby tubers	Badly scabbed tubers
						%	%	%
Lime	51	63	269	112	474	14.2	60.5	25.3
Potassium carbonate	50	60	263	71	394	15.2	66.7	18.1
Ammonium sulphate	58	139	226	5	374	37.5	60.1	1.4
Potassium sulphate	42	112	221	51	384	29.2	57.5	13.3
Sulphur	52	97	310	32	439	22.1	70.6	7.3

The advantage gained by the use of ammonium sulphate and of sulphur as compared with lime or potassium carbonate is apparent at a glance. Practically all the tubers grown where ammonium sulphate was applied were marketable, although a majority of them were slightly scabbed. The tubers from the sulphur-treated rows were not of quite as high grade. The potassium sulphate rows might be regarded as controls, for it is doubtful if this salt produced any effect whatsoever. The two alkaline applications, lime and potassium carbonate, seemed to aggravate the trouble. An average percent of scab on ten varieties, exclusive of five somewhat resistant varieties grown on land immediately adjacent, was: 18.2% of clean, 66.8% of slightly scabby, and 15.0% of badly scabbed tubers. These figures serve as a check on the above treatments.

Effects of Fertilizers and Chemicals on the Thickness of Skin

The studies made for a number of years at this Station, both in the field and laboratory, have conclusively shown that the thickness of the corky layers of the potato tuber had a decided influence on its resistance to the potato scab organism. Furthermore, it has been noted that the application to the soil of certain chemicals, such as sulphur and ammonium sulphate, enables even very susceptible varieties to some extent to withstand the ravages of the scab organism. The question naturally arises, therefore, whether there is possible connection between these two apparently related observations.

It must be noted, of course, that there are at least two possible effects that the addition of a chemical or fertilizer may have on the soil; it may affect either the parasite itself or its host plant. Under the conditions usually present in soil sulphur becomes oxidized and the ammonium sulphate molecule is cleaved in the soil, sulphur compounds, probably weak acids, being produced. It is assumed in the latter instance that the ammonia is oxidized to nitric acid while the free or uncombined sulphuric acid unites with the calcium of the calcium carbonate of the soil forming sulphate of lime and freeing carbon dioxid. The abnormal amount of acid thus formed undoubtedly serves to retard the growth of the scab Actinomyces. Furthermore it seems quite probable that the ions released when sulphur or ammonium sulphate are used exhibit an inhibitory toxic effect on their increase, an effect entirely distinct from and, it may be said, supplementary to induced acidity. Then again it is quite possible that such chemicals as sulphur

and ammonium sulphate applied to a soil may tend to stimulate the cork cambium to produce an unusually large number of cell layers, thus resulting in a very thick skin. On the other hand, such substances as lime or fresh manure may tend to inhibit such cambial divisions and, as a consequence, the skin of the tubers grown in areas thus treated may be found to be even thinner than is the case when tubers are grown on an ordinary unfertilized soil.

Kreitz (14) has done some interesting work touching the relation of the thickness of the tuber skin to soil, moisture and fertilizers. It is the latter factor that is of particular interest in the present study. Kreitz grew Dabersche potatoes on a piece of land which had received its last application of stable manure two years previous to the use for experimental purposes. His results are summarized in the following table:

TABLE X—EFFECT OF FERTILIZERS ON THE THINNESS OF SKIN LAYERS

	Thickness of skin microns	Number of cell layers
Kainit, 150 pounds per acre	208	8.3
Lime, 3,750 pounds per acre	240	8.3
Sodium nitrate, 50 pounds per acre	272	9.7
Salt, 270 pounds per acre	272	10.7
Acid phosphate, 150 pounds per acre	320	13.3
Control	288	11.3

In spite of these differences in thicknesses, the skin of the tubers, to all external appearances, seemed to be alike in all cases. It will be noticed that following the application of lime the skin was much thinner, while following that of the acid phosphate the reverse was the fact. Practical growers in this country often claim that the addition of too much fertilizer results in a russetting and irregular thickening of the skin of the tubers, but no one has observed that the liming of land makes potatoes thinner skinned. Sorauer, quoted by Kreitz (14), made the observation in 1871 that the skin of tubers on freshly manured land was thinner than that on land where the manure had been applied some time previously. He also found that varieties with red skins were less susceptible to the rot caused by *Phytophothora infestans* than the white skinned ones and connected up this fact with the thicker skins of the red types. Other authors, quoted in this same paper by Kreitz, are of the opinion that the smooth skinned varieties are less susceptable to the attacks of *P. infestans* because they furnish no lodging place for the spores.

The methods used in the present study of potato skins was essentially the same as those recommended by Lee (15) for sectioning animal tissues on a freezing microtome. In order to carry this through successfully preliminary treatment was found to be necessary. Small pieces of potato about 1×½×½ c. c. were dropped for 24 hours in a soaking solution, composed of equal parts of: 4 ounces of gum arabic dissolved in 6 ounces of water; 1 pound of loaf sugar boiled into solution in 1 pint of boiling water. Before freezing, the gum arabic-sugar solution was wiped from the block and it was frozen in the gum mucilage solution alone. The knife was kept covered with water and, as rapidly as the sections were cut, they were transferred to a dish of water. The gum and sugar soaked out of them and they resumed their normal size and shape.

The processes where the cork layers were stained in order to secure a differential stain was essentially the same as those recommended by Kreitz and ascribed by him to Tison. They were now placed for at least a few hours in a very weak alkaline solution of gentian violet, so highly diluted as to be quite transparent. The sections were then removed from this solution and washed in an eight per-cent solution of hydrochloric acid. The color was removed by this treatment from all of the walls except those impregnated by suberin A short wash in tap water was necessary to restore this color at times to these portions. The sections were then spread on slides in 10 per-cent glycerin which was exposed to the air for 24 hours without a cover glass. At the end of this time the fluid had become quite concentrated and a little 50 percent glycerin was added, the sections were covered and examined. The stain gradually soaked out of the cork layer, but it was not necessary to examine the sections for some time.

The first series studied in this way were grown in the summer of 1916 on land on which potatoes had been planted the previous year. The tubers were stored in paper bags in the greenhouse basement and examined from time to time during the winter. The fact that the examination extended over five or six months made the author very doubtful as to the accuracy of the results, since in the intervening time an opportunity might have been afforded for the cork layers to increase in thickness. The first series were made from these potatoes, however, and the results are presented in the following tables, about which a few explanations seem necessary.

Kreitz gives no indication as to the allowance which he made for differences in the thickness of the skin in russetted as compared with

clear portions. The majority of the potatoes studied here showed some portions of the skin very much thicker than others. It was something of a problem to decide just what disposal to make of them.

It was finally decided to separate entirely the two sorts of measurements and then to try, in some cases, to combine them in about the proportion in which they seemed to occur in the sections. The data derived from the examination the thin portion seemed likely to be more nearly comparable to that used by Kreitz. An average of about 50 measurements were taken but it was found to be very difficult to avoid picking places that were thick or thin, that is to say it was almost impossible to eliminate the personal equation. An examination of the results will show that they are not at all consistent on the various sorts tested. The cell layers on the russetted portions, moreover, are often very confused and broken, so that it is probable that the thickness in the thinner portions more nearly represents the correct thickness.

The growing reason of 1916 was an abnormal one which may further explain the decidedly divergent results secured. The potatoes were grown on very light sandy soil and the tubers were almost baked during the extreme weather of early August.

Chemicals were applied as follows: Salt, 700 pounds; sodium nitrate, 128 pounds; slaked lime, 8,300 pounds; fresh manure, liberal dressing; sulphur, 435 pounds; acid phosphate, 390 pounds; commercial fertilizer, 2,000 pounds; coal ashes, 9,500 pounds; ammonium sulphate, 300 pounds. The potato fertilizer used contained 3.3% nitrogen, 13% total phosphoric acid, 8.8% available phosphoric acid and 8.8% potash. The nitrogen was derived in part from nitrate of soda and in part from tankage.

TABLE XI—EFFECT OF CHEMICALS ON THICKNESS OF THE SKINS OF POTATO TUBERS

Variety	Chemical or fertilizer used	Cell layers in thick portion	Cell layers in thin portion	Thickness, thick portion	Thickness, thin portion	Maximum thickness	Minimum thickness
				microns	microns		
Dibble's Russet	Salt	10.3	6.8	164.3	102.1	14 cells 207.2 microns	5 cells 74 microns
	Sodium nitrate	9.6	6.6	168.7	112.5	12 cells 207.2 microns	5 cells 74 microns
	Slaked lime	10.3	6.9	180.6	119.9	14 cells 266.4 microns	5 cells 88.8 microns
	Fresh manure	10.4	6.5	179.1	117	12 cells 207.2 microns	5 cells 74 microns
	Sulphur	11.8	7.5	202.8	125.8	18 cells 266.4 microns	5 cells 88.8 microns
	Acid phosphate	10.2	7.4	186.4	122.8	12 cells 236.8 microns	5 cells 88.8 microns
	Complete fertilizer	14.6	7.4	222	130.2	18 cells 281.2 microns	5 cells 88.8 microns
	Coal ashes	10.7	7.3	186.5	112.5	14 cells 207.2 microns	5 cells 74 microns
	Ammonium sulphate	10.3	7.7	186.5	125.8	13 cells 266.4 microns	6 cells 88.8 microns
	Control	11.2	7.9	192.4	136.2	15 cells 251.6 Microns	6 cells 88.8 microns
Green Mountain	Salt	11.6	..	210.8	....	15 cells 255 microns	9 cells 170 microns
	Sodium nitrate	11.8	..	224.4	....	16 cells 306 microns	8 cells 153 microns
	Slaked lime	10.5	..	187	....	15 cells 255 microns	6 cells 119 microns
	Fresh manure	No data, potatoes lost					
	Sulphur	14	..	251.6	....	18 cells 306 microns	11 cells 187 microns
	Acid phosphate	13	..	224.4	....	16 cells 289 microns	10 cells 170 microns
	Complete fertilizer	10.2	..	171.6	....	13 cells 221 microns	8 cells 136 microns
	Coal ashes	12.4	..	210.8	....	16 cells 255 microns	10 cells 170 microns
	Ammonium sulphate	11.2	..	192.1	....	15 cells 238 microns	8 cells 153 microns
	Control	12.5	..	210.8	....	17 cells 272 microns	9 cells 136 microns

TABLE XI—EFFECT OF CHEMICALS ON THICKNESS OF THE SKINS OF POTATO TUBERS—*continued*

Variety	Chemical or fertilizer used	Cell layers in thick portion	Cell layers in thin portion	Thickness, thick portion	Thickness, thin portion	Maximum thickness	Minimum thickness
				microns	microns		
Early Rose	Salt	12	238	....	....	16 cells 306 microns	10 cells 187 microns
	Sodium nitrate	11.3	207.4	....	....	15 cells 255 microns	9 cells 170 microns
	Slaked lime	11.6	215.9	....	....	15 cells 255 microns	9 cells 170 microns
	Fresh manure	11.2	210.8	....	....	14 cells 255 microns	9 cells 170 microns
	Sulphur	11.4	209.1	....	....	16 cells 255 microns	8 cells 153 microns
	Acid phosphate	11.1	192.8	....	....	14 cells 255 microns	8 cells 170 microns
	Complete fertilizer	10	183.6	....	....	13 cells 221 microns	7 cells 136 microns
	Coal ashes	10.8	203.2	....	....	15 cells 255 microns	8 cells 153 microns
	Ammonium sulphate	10.9	205.7	....	....	14 cells 255 microns	9 cells 170 microns
	Control	11.4	207.4	....	....	15 cells 272 microns	9 cells 153 microns
Scab Proof	Salt	19.4	9.4	307.7	147.9	23 cells 391 microns	7 cells 102 microns
	Sodium nitrate	17	8.8	272	139.4	22 cells 391 microns	7 cells 85 microns
	Slaked lime	15.7	9.2	232.9	127.5	20 cells 289 microns	7 cells 85 microns
	Fresh manure	16.5	8.7	260.1	141.1	20 cells 306 microns	7 cells 85 microns
	Sulphur	19	9.6	323	158.1	24 cells 425 microns	8 cells 119 microns
	Acid phosphate	16.7	8	275.4	128.2	20 cells 340 microns	6 cells 85 microns
	Complete fertilizer	17.3	8.5	277.1	133.8	21 cells 340 microns	6 cells 102 microns
	Coal ashes	17.5	8.2	280.5	136.6	21 cells 340 microns	6 cells 102 microns
	Ammonium sulphate	16.4	8	268.6	130.9	20 cells 340 microns	6 cells 85 microns
	Control	17	8.5	283.9	147.9	20 cells 374 microns	7 cells 102 microns

TABLE XI—EFFECT OF CHEMICALS ON THICKNESS OF THE SKINS OF POTATO TUBERS—*concluded*

Variety	Chemical or fertilizer used	Cell layers in thick portion	Cell layers in thin portion	Thickness, thick portion	Thickness, thin portion	Maximum thickness	Minimum thickness
				microns	microns		
Bovee (smooth potato)	Salt	10.5	229.46	8.3	172.48	.....	.....
	Sodium nitrate	none	none	7.1	152.46	.....	.....
	Slaked lime	none	none	10.2	229.46	.....	.....
	Fresh manure	10.5	227.44	8.1	160.16	.....	.....
	Sulphur	none	none	9.4	184.8	.....	.....
	Acid phosphate	none	none	7.3	160.16	.....	.....
	Complete fertilizer	11.9	226.38	7.7	155.54	.....	.....
	Coal ashes	10.3	212.52	7.6	158.62	.....	.....
	Ammonium sulphate	none	none	7.5	146.3	.....	.....
	Control	none	none	8.2	197.12	.....	.....
Russetted potato	Sodium nitrate	11.7	235.62	8.2	160.1	.....	.....
	Sulphur	11.5	264.88	9.0	164.8	.....	.....
	Ammonium sulphate	11.3	229.46	7.3	150.9	.....	.....

The results are not at all conclusive. An attempt was made with the Green Mountain tubers to arrive at an average of the thick and thin portions in the sections and to sum these up in one set of figures. No decided difference could be seen as a result of the treatment, expressed either as numbers of cell-layers or as thickness in microns. The maximum and minimum thicknesses also show only small differences, although it is true that a slightly thicker skin was observed on areas on which sulphur was spread and a somewhat thinner skin on those where lime was used.

Bovee is not at all consistent, either as to the cell layers or the thickness of the skin. The use of salt, sodium nitrate, lime and of fresh manure was followed by thinning of the skin in Dibble's Russet.

but sulphur and ammonium sulphate applications were followed by a thinner skin on the thin portions and in only a slightly thicker skin on the thicker portions from the sulphur.

Neither Early Rose nor Scab Proof manifested skin differences following these treatments, although in the latter instance when sulphur was used the skin was slightly thicker than the average, both in cell layers and in microns.

Several reasons may be advanced as to the inconclusiveness of these results.

(1) The chemicals may have leached from the light sandy soil thus minimizing their effect.

(2) The unusual season may have induced the formation of skins of relatively similar thicknesses regardless of the divergencies in chemical applications.

(3) The long winter storage of the tubers may have given the cork cambium a chance to continue growth, thus equalizing any differences in cork thickness which may have existed at harvest.

The 32 results were so inconclusive that the trial was repeated in 1917 on another piece of land, a sandy loam, somewhat different than that heretofore used. The amounts of fertilizer used were the same as in the previous year. The plants died prematurely from a combination of mosaic and tip burn, but formed enough tubers for the present studies. Many of the tubers, even when smooth, showed an abnormal browning under the cork layers, the cause of this trouble not being apparent. Circumstances made it impossible to cut the sections immediately after harvest and, consequently, the tubers were stored in soil in a greenhouse cellar for about six months. The soil and tubers were dampened and apparently no change took place in the superficial appearance of the skin.

TABLE XII—EFFECT OF CHEMICALS ON THICKNESS OF SKIN OF POTATO TUBERS

Variety	Chemicals or fertilizer used	Clean White Tubers				Russetted Tubers			
		Cell layers in thick portion	Cell layers in thin portion	Thickness in thick portion	Thickness in thin portion	Cell layer in thick portion	Cell layer in thin portion	Thickness in thick portion	Thickness in thin portion
				microns	microns			microns	microns
Dibble's Russet	Fresh manure	11.33	8.19	153	116.5	23.4	...	230	...
	Acid phosphate	13.29	7.37	198.4	110	17	...	264	...
	Lime	9	7	115	84.4	...	...	....	...
	Salt								
	(Large tubers)	11.08	7.9	157.5	113	...	...	....	...
	(Small tubers)	10.5	7.3	160	103.7	...	...	....	...
	Control	10.9	6.76	137	100	14.4	6.85	167	78
	Control (Smooth part of potato)	12.5	6.72	145	100	...	...	....	..
	Sulphur	11	8.14	188	121	10.6	6.22	138	89.2
	Sulphur (Potato browned)	13.8	none	200	none	...	...	....	...
	Ammonium sulphate	9	7	145	102	...	...	....	...
	(Large white)	....	...	....	....	...	...	....	...
	(Small white)	10.4	7.04	130	95	...	...	....	...
	(Russetted large)	....	...	....	....	11	7	155.9	94.2
Green Mountain	Acid phosphate								
	(Small tubers)	9.5	6.9	125	90.3	...	...	....	...
	(Large tubers)	10	6.8	130	92.5	...	...	....	...
	Salt	11.9	7.1	140	87.5	...	...	....	...
	Fresh manure	9.6	7.3	126	109	11.1	6.8	151	100
	Ammonium sulphate	9	7	150	94.4	13.3	6.5	152	92.5
	Sulphur	....	7.1	....	93.6	...	...	....	...
	Lime	9	6.5	126.6	92.2	9.9	6.5	128.8	96
Green Mountain (from-nursery plot)	Acid phosphate	12	7.85	170	129	10.7	7.45	145	54.5
	Sulphur	12.5	7.92	138.3	90	...	...	....	...
	Fresh manure	....	8.3	83	....	12.8	6.6	146	76.6
	Fresh manure (Potato browned)	....	...	....	....	...	13.1*	....	195.5
	Ammonium sulphate	16.4	6.5	214	75	...	...	....	...

*The 13.1 cell layers were composed of 5.1 layers of cork and 8 layers of tissue, which was apparently abnormal and gave the brown appearance to the surface. The total thickness, 195.5 microns was made up of 105 microns of cork and 90.5 microns of this other type of tissue.

Only two varieties—Dibble's Russet and Green Mountain—were used. Various combinations were tried in the collection of the data in the hope of ascertaining whether any changes occurred in the skins following the several soil treatments. Minor fluctuations in the cell layers and in the thickness in microns are to be observed but nothing that seems to indicate that the chemicals altered the skin, except that when sulphur was used both the number of the cell layers and the thickness of the skin seemed to be increased. The cell layers resulting from the treatment with fresh manure were almost as numerous as those from the sulphur, and yet manure helps the scab organism whereas sulphur seems to retard its growth.

The Green Mountain potatoes taken from another plot at some distance from the first set seemed to exhibit a somewhat thicker skin. The soil of this plot (known as the nursery plot) was even sandier than that on which the other Green Mountains and Dibble's Russets grew. The results received when sulphur, fresh manure and ammonium sulphate were applied were the opposite of those to be expected in view of the effect produced by these chemicals on the amount of scab; that is to say, these treatments seemed to make the skin thinner.

These general results were so inconclusive that trials were made by plate cultures on the effect on the bacteria of the Actinomyces chromogenus group. No conclusions could be drawn from the results obtained. The soil samples were taken in the furrows where the chemicals had been distributed, the dilutions were plated out on nutrient agar and counts made of the organisms producing a distinctly brown color around the colonies. Güssow (8) and Dreschler (5) contend that only a portion of the A. chromogenus group (known by them as A. scabies) is parasitic. Even if this be true, probably it would not affect these counts, since all of this group would be likely to be influenced in about the same way by the chemicals employed in the soil. The counts showed no decided differences followni these various treatments. It is the belief of the writer, however, that such chemicals as sulphur affect the scab organism rather than the thickness of the tuber skin. The effect on the organisms may not result in a decided decrease in their numbers, but their vigor and pathogenicity may be weakened.

GENERAL CONCLUSIONS

1. The thickness of the skin determines the resistance of the tubers to scab. Color seems to play no role in this resistance. All russet varieties seem at least moderately resistant.

2. Close textured lenticels, partly buried under the skin surface and filled with small cells, are also associated with the russet type of potatoes.

3. The application of certain fertilizers and chemicals to the soil affects to some extent the amount of scab, sulphur and ammonium sulphate tending to decrease and lime and manure to increase it.

4. The skin structure seems to be but slightly affected by these applications, at least on sandy soil; hence it seems probable that any changes which they may bring about in the prevalence of scab is due to their effect on the numbers or the pathogenicity of the organisms rather than on the tuber itself.

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FERTILIZERS
COMMERCIAL FEEDING STUFFS
AGRICULTURAL SEED

(INSPECTION BULLETIN)

BURLINGTON
FREE PRESS PRINTING COMPANY
1919

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BULLETIN 216: COMMERCIAL FERTILIZERS, COMMERCIAL FEEDING STUFFS, AGRICULTURAL SEED

By J. L. Hills, C. H. Jones, G. F. Anderson and L. H. Flint

The results of the police work performed during 1919 by the Station in accordance with state laws is set forth in condensed form in this bulletin. The Station regrets its inability to furnish the full information touching these important matters which heretofore has been vouchsafed.

It may be said in brief:

Fertilizer Control. That a larger proportion of the brands than usual were found to be deficient. Nearly one in four failed in some respect to make good manufacturers' promises.—Pages 3-16.

Feeding Stuffs Inspection. That the results were about normal, only a few brands being seriously deficient.—Pages 16-26.

Agricultural Seed Inspection. That a very large part of the lots were not guaranteed and fully one in ten was not as pure as it was said to be.—Pages 26-32.

FERTILIZER CONTROL

The sampling agents of the Station visited 85 cities, towns and villages in Vermont in April and May, 1919, and drew 356 samples from dealer's stocks, representing 130 of the brands of commercial fertilizers licensed for sale by the following companies:

Licensees	Licensed brands	Brands sampled
American Agricultural Chemical Co.	40	38
Armour Fertilizer Works	6	6
Bowker Fertilizer Co.	7	7
Burlington Rendering Co.	5	5
Coe-Mortimer Co.	9	9
Essex Fertilizer Co.	7	6
International Agricultural Corporation—		
Buffalo Fertilizer Works	8	8
Listers' Agricultural Chemical Works	7	7
Lowell Fertilizer Co.	9	8
National Fertilizer Co.	9	7
New England Fertilizer Co.	7	5
Nitrate Agencies Co.	4	2
C. S. Page	1	1
Parmenter & Polsey Fertilizer Co.	3	2
Reading Bone Fertilizer Co.	7	5
Rogers & Hubbard Co.	6	6
F. S. Royster Guano Co.	7	5
Sanderson Fertilizer and Chemical Co.	3	3
	145	130

No samples of the following brands were found on sale by the station sampling agents. In some cases no shipments whatever appear to have been made, in other but small ones.

American Agricultural Chemical Co.'s Complete Tobacco Manure without Potash.
American Agricultural Chemical Co.'s Bradley's Potato Fertilizer 1919.
Essex Fertilizer Co.'s Potato Phosphate.
Lowell Fertilizer Co.'s Potato, Corn and Vegetable.
National Fertilizer Co.'s Five-Four Tobacco Manure.
National Fertilizer Co.'s Pine Tree State Potato Fertilizer.
New England Fertilizer Co.'s Corn Phosphate.
New England Fertilizer Co.'s High Grade Potato.
Nitrate Agencies Co.'s 1/10 Grain Formula.
Nitrate Agencies Co.'s 2/10 Corn Formula.
Parmenter & Polsey Fertilizer Co.'s Plymouth Rock Brand.
Reading Fertilizer Co.'s Farmers' Tankage and Potash for Corn, Grain and Grass.
Reading Fertilizer Co.'s Truck, Tree, Fruit, Vine, Potato and Tobacco Grower.
F. S. Royster Guano Co.'s Corn and Oats Ammoniated Phosphate.
F. S. Royster Guano Co.'s Truckers' Delight Guano.

The following condensed statements set forth the essential facts as to the maintenance of guaranties. The order of statement is alphabetical by names of manufacturers.

The first four figures in the table, reading horizontally following the brand name, indicate what the manufacturers' promises were, expressed in percentage terms; and the word following, usually "Yes," less often "No," tells in this laconic, straightforward fashion whether or not the promises have been kept. The remaining words and figures, other than the last two, show the quality of the nitrogen. By the use of the words "Passed" or "Not Passed" the character of the organic nitrogen is set forth. The former word is used whenever the analysis indicated a good or passable grade; the latter when it did not. The next two horizontal statements in terms of figures indicate the proportions of the total nitrogen present in water-soluble and water-insoluble forms. The former includes nitrate nitrogen, ammoniacal nitrogen and such organic nitrogen as is water-soluble. The last figure, reading horizontally, indicates in terms of decimal fractions what proportion of the total phosphoric acid is furnished in available form. The last column shows by the presence of the letter C or S as the case may be whether the potash, if present, was present as muriate or chlorid (C) or as sulphate (S). In case both were present, the letters CS or SC are used, the one first given indicating predominance. The figures in parenthesis, i. e. (23), refer to the matter on pages 10 to 13 "Concerning deficiencies."

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

BRAND	Guaranties				Guaranty met?	Quality organic nitrogen?	Nitrogen		Proportion total phos. acid available	Potash, as muriate (C) or sulphate (S)
	Nitrogen	Total phosphoric acid	Available phosphoric acid	Potash			Water soluble	Water insoluble		
American Agricultural Chemical Company, 92 State St., Boston, Mass.										
Ammoniated Fertilizer A	0.82	11	10	..	Yes	Passed	.7	.3	.9	..
Ammoniated Fertilizer AA	1.65	11	10	..	Yes	Passed	.4	.6	.9	..
Ammoniated Fertilizer AAA	2.47	11	10	..	Yes	Passed	.8	.2	.9	..
Ammoniated Fertilizer AAAA	3.29	11	10	..	Yes	Passed	.7	.3	.8	..
Cereal and Root Fertilizer	2.47	11	10	..	Yes	Passed	.6	.4	.8	..
Complete Potato Mixture	2.47	9	8	3	Yes	Passed	.7	.3	.9	C
Extra Quality Potato Manure	4.11	11	10	..	? (1)	Passed	.7	.3	.9	..
General Crop Grower, 1919	1.65	11	10	1	Yes	Passed	.5	.5	.9	C
Grain and Seeding Fertilizer	1.65	11	10	..	Yes	Passed	.5	.5	.9	..
Grass and Oats Fertilizer	...	12	11	2	No (1a)	.....	..	..	.9	S
High Grade Fertilizer, 1916	2.47	10	9	1	No (2)	Passed	.7	.3	.9	CS
Odorless Grass and Lawn Top Dressing, without Potash	4.11	11	10	..	Yes	Passed	.7	.3	.8	..
Special Vegetable Fertilizer	3.29	11	10	..	Yes	Passed	.7	.3	.9	..
Two-Eight-Three	1.65	9	8	3	Yes	Passed	.7	.3	.9	C
(Bradley Fertilizer Company brands)										
Complete Manure for Potatoes and Vegetables, 1916	3.29	10	9	1	Yes	Passed	.7	.3	.8	C
Corn Phosphate, 1916	1.65	11	10	1	Yes	Passed	.4	.6	.9	C
Grain Fertilizer	0.82	11	10	..	Yes	Passed	.7	.3	.9	..
Maine Potato Special	4.11	11	10	..	Yes	Passed	.8	.2	.9	..
Potato Manure, 1916	2.47	10	9	1	? (3)	Passed	.8	.2	.9	C
Root Crop Manure	3.29	11	10	1	Yes	Passed	.7	.3	.9	..
Special Corn Phosphate without Potash	1.65	11	10	..	No (4)	Passed	.5	.5	.9	..
Special Eclipse Phosphate	0.82	9	8	1	? (5)	Passed	.5	.5	.9	C
Special Potato Fertilizer without Potash	1.65	11	10	..	Yes	Passed	.4	.6	.9	..
Special Potato Manure without Potash	2.47	11	10	..	Yes	Passed	.7	.3	.8	..
Special XL Superphosphate without Potash	2.47	11	10	..	Yes	Passed	.8	.2	.8	..
XL Superphosphate of Lime, 1916	2.47	10	9	1	Yes	Passed	.8	.2	.9	C
(Crocker Fertilizer and Chemical Company brands)										
Ammoniated Corn Phosphate, 1916	2.06	9	8	1	Yes	Passed	.4	.6	.9	C
New Rival Ammoniated Superphosphate, 1916	0.82	11	10	1	Yes	Passed	.5	.5	.8	C
Potato, Hop and and Tobacco Fertilizer, 1916	2.06	11	10	1	No (6)	Passed	.6	.4	.9	C
(Great Eastern Fertilizer Company brands)										
General, 1916	0.82	9	8	1	Yes	Passed	.3	.7	1.0	C
Northern Corn Special, 1916	2.06	9	8	1	Yes	Passed	.3	.7	.8	C
Potato Manure, 1916	2.06	11	10	1	Yes	Passed	.4	.6	.9	CS

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

BRAND	Guaranties				Guaranty met?	Quality organic nitrogen?	Nitrogen		Proportion total phos. acid available (%) or sulphate (S)
	Nitrogen	Total phosphoric acid	Available phosphoric acid	Potash			Water soluble	Water insoluble	
(Pacific Guano Company brands)									
Special Potato Fertilizer without Potash	1.65	11	10	..	Yes	Passed	.7	.3	.9 ..
Special Soluble Pacific Guano without Potash	1.65	11	10	..	Yes	Passed	.6	.4	.8 ..
(Quinnipiac Company brands)									
Special Corn Manure without Potash	1.65	11	10	..	Yes	Passed	.4	.6	.9 ..
Special Potato Phosphate, without Potash	1.65	11	10	..	Yes	Passed	.4	.6	.9 ..
(Williams & Clark Fertilizer Company brands)									
Special Americus Corn Phosphate without Potash	1.65	11	10	..	Yes	Passed	.6	.4	.8 ..
Special Americus Potato Manure without Potash	1.65	11	10	..	Yes	Passed	.5	.5	.7 ..
Armour Fertilizer Works, 1501-1514 Munsey Building, Baltimore, Md.									
Four-Ten-Zero Fertilizer	3.29	10.5	10	..	Yes	Passed	.7	.3	.8 ..
Grain Grower Two-Eight-Two Fertilizer	1.65	8.5	8	2	Yes	Not passed (7)	.5	.5	.9 CS
Crop Grower One-Eight-Two Fertilizer	0.82	8.5	8	2	Yes	Not passed (8)	.6	.4	.9 SC
Two-Eight-Three Fertilizer	1.65	8.5	8	3	Yes	Passed	.4	.6	.8 SC
Two-Ten-Zero Fertilizer	1.65	10.5	10	..	Yes	Passed	.3	.7	.8 ..
Wheat, Corn and Oats Special One-Seven-One	0.82	7.5	7	1	Yes	Not passed (9)	.5	.5	.9 C
Bowker Fertilizer Company, 43 Chatham St., Boston, Mass.									
Four-Ten Hill and Drill	3.29	11	10	..	Yes	Passed	.7	.3	.9 ..
One-Ten Sure Crop	0.82	11	10	..	Yes	Passed	.4	.6	.9 ..
Potato Phosphate, 1916	1.65	11	10	1	Yes	Passed	.7	.3	.9 C
Stockbridge General Crop Manure, 1916	3.29	10	9	1	Yes	Passed	.7	.3	.9 C
Three-Ten All Round	2.46	11	10	..	Yes	Passed	.7	.3	.9 ..
Two-Ten Farm and Garden	1.65	11	10	..	Yes	Passed	.4	.6	.9 ..
Three-Eight-Three Complete	2.47	9	8	3	Yes	Passed	.8	.2	.9 CS
Burlington Rendering Company, North Ave., Burlington, Vt.									
Animal Fertilizer 3/10	2.46	11	10	..	No (10)	Passed	.6	.4	.7 ..
Grain Fertilizer 1½/10	1.23	11	10	..	Yes	Passed	.6	.4	.9 ..
Potato Fertilizer 4/10	3.28	11	10	..	Yes	Passed	.5	.5	.6 ..
Burlington Fertilizer 1/10	0.82	11	10	..	Yes	Not passed (11)	.4	.6	.8 ..
Burlington Fertilizer 2/8/2	1.64	9	8	2	Yes	Passed	.7	.3	.9 C

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

BRAND	Guaranties				Guaranty met?	Quality organic nitrogen?	Nitrogen		Proportion total phos. acid available	Potash, as muriate (C) or sulphate (S)
	Nitrogen	Total phosphoric acid	Available phosphoric acid	Potash			Water soluble	Water insoluble		
Coe-Mortimer Company, 51 Chambers St., New York, N. Y.										
E. Frank Coe's Columbian Corn and Potato Fertilizer, 1916	1.23	11	10	1	Yes	Passed	.5	.5	.9	C
E. Frank Coe's High Grade Ammoniated Superphosphate, 1916	2.47	11	10	..	Yes	Passed	6.	.4	.9	..
E. Frank Coe's Matchless Root Grower	1.65	9	8	3	Yes	Passed	.7	.3	.9	CS
E. Frank Coe's New Englander Special, 1916	0.82	9	8	1	Yes	Passed	.6	.4	.9	C
E. Frank Coe's Original Ammoniated Dissolved Phosphate, 1916	1.65	11	10	..	No (12)	Passed	.6	.4	.8	..
E. Frank Coe's Prolific Crop Producer, 1916	4.11	11	10	..	Yes	Passed	.7	.3	.9	..
E. Frank Coe's Standard Potato Fertilizer, 1916	3.29	10	9	1	Yes (13)	Passed	.7	.3	.9	C
E. Frank Coe's Top Dressing Manure, 1916	6.58	9	8	..	Yes	Passed	.9	.1	.8	..
E. Frank Coe's XXV Ammoniated Phosphate, 1916	0.82	11	10	..	Yes	Passed	.4	.6	.9	..
Essex Fertilizer Company, 89 North Market St., Boston, Mass.										
Bone Fertilizer	1.64	11	10	..	Yes	Not passed (14)	.5	.5	.7	..
Fish Fertilizer	2.46	11	10	..	No (15)	Passed	.7	.3	.8	..
Grain, Grass and Potato Fertilizer	0.82	13	10	..	Yes	Not passed (16)	.5	.5	.9	..
Market Garden	2.87	11	10	..	Yes	Passed	.6	.4	.7	..
Two-Eight-Two	1.64	9	8	2	Yes	Passed	.6	.4	.9	C
Two-Eight-Four	1.64	9	8	4	No (17)	Not passed (17)	.6	.4	.9	C
International Agricultural Corporation Buffalo Fertilizer Works, 812 Marine Bank Building, Buffalo, N. Y.										
Buffalo Ammoniated Phosphate	1.23	13	12	..	Yes	Passed	.6	.4	.8	..
Buffalo Farmers' Choice	0.82	11	10	..	Yes	Passed	.5	.5	.8	..
Buffalo General Favorite	0.82	9	8	1	No (18)	Passed	.6	.4	.8	C
Buffalo New England Special	1.65	11	10	..	Yes	Passed	.6	.4	.8	..
Buffalo Onion, Vegetable and Potato	2.47	11	10	..	Yes	Passed	.7	.3	.9	..
Buffalo Phosphate and Potash.	...	11	10	2	Yes	Passed	..	..	.9	C
Buffalo Tip Top	0.82	9	8	2	Yes	Not passed (19)	.6	.4	.8	C
Buffalo Triumph	1.65	9	8	2	Yes	Passed	.6	.4	.7	C

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

BRAND	Guaranties				Guaranty met?	Quality organic nitrogen?	Nitrogen		Proportion total phos. acid available
	Nitrogen	Total phosphoric acid	Available phosphoric acid	Potash			Water soluble	Water insoluble	Potash, as muriate (C) or sulphate (S)
Listers' Agricultural Chemical Works, Lister Ave., Newark, N. J.									
Crescent Ammoniated Superphosphate, 1916	1.65	11	10	..	Yes	Passed	.4	.6	.7 ..
Excelsior Guano, 1916	2.47	11	10	..	Yes	Passed	.7	.3	.8 ..
Grain and Grass Fertilizer, 1916	0.82	11	10	..	Yes	Not passed (20)	.6	.4	.9 ..
One-Eight-Two Fertilizer	0.82	9	8	2	? (21)	Not passed (21)	.3	.7	.9 C S
Revised Vermont Corn and Potato Fertilizer	0.82	9	8	1	? (22)	Not passed (22)	.3	.7	.9 C
Special Corn and Potato Fertilizer, 1916	2.06	9	8	1	Yes	Passed	.5	.5	.6 C
Success Fertilizer, 1916	1.23	11	10	1	Yes	Passed	.5	.5	.8 C
Lowell Fertilizer Company, 40 North Market St., Boston, Mass.									
Animal Brand	2.87	11	10	..	No (23)	Passed	.8	.2	.6 ..
Bone Fertilizer	2.05	11	10	..	Yes	Not passed (24)	.8	.2	.8 ..
Dissolved Bone Fertilizer	1.64	11	10	..	Yes	Not passed (25)	.8	.2	.7 ..
Empress Brand	1.23	11	10	..	Yes	Passed	.7	.3	.9 ..
Potato Manure	2.46	11	10	..	Yes	Passed	.8	.2	.8 ..
Potato Phosphate	3.28	11	10	..	Yes	Passed	.8	.2	.8 ..
Sterling Phosphate	0.82	13	10	..	Yes	Not passed (27)	.6	.4	.8 ..
National Fertilizer Company, 92 State St., Boston, Mass.									
Eureka Potato Fertilizer, 1916	2.47	10	9	1	Yes	Passed	.8	.2	.8 C
Nitrogen Phosphate Mixture No. 2	1.65	11	10	..	Yes	Passed	.7	.3	.9 ..
Nitrogen Phosphate Mixture No. 3	2.47	11	10	..	Yes	Passed	.8	.2	.9 ..
Nitrogen Phosphate Mixture No. 4	3.29	11	10	..	Yes	Passed	.8	.2	.9 ..
Tobacco Special without Potash	4.53	4	3	..	Yes	Passed	.9	.1	.7 ..
Universal Grain and Potato Fertilizer	0.82	9	8	1	? (28)	Passed	.5	.5	.9 C S
XXX Fish and Potash, 1916	2.06	11	10	1	Yes	Passed	.8	.2	.9 C
New England Fertilizer Company, 40A North Market St., Boston, Mass.									
Corn and Grain Fertilizer	1.23	11	10	..	Yes	Not passed (29)	.7	.3	.8 ..
Potato Fertilizer	2.46	11	10	..	Yes (30)	Passed	.8	.2	.8 ..
Standard Phosphate	0.82	13	10	..	Yes	Not passed (31)	.7	.3	.9 ..
Superphosphate	2.87	11	10	..	Yes	Passed	.8	.2	.8 ..
Two-Eight-Four	1.64	9	8	4	Yes	Not passed (32)	.7	.3	.9 C

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

BRAND	Guaranties				Guaranty met?	Quality organic nitrogen?	Nitrogen		Proportion total phos. acid available	Potash, as muriate (C) or sulphate (S)
	Nitrogen	Total phosphoric acid	Available phosphoric acid	Potash			Water soluble	Water insoluble		
Nitrate Agencies Company, 85 Water St., New York, N. Y.										
4/10 Universal Mixture	3.29	11	10	..	Yes	Passed	.8	.2	.9	..
3/10 Corn and Potato	2.46	11	10	..	No (33)	Passed	.8	.2	.9	..
Carroll S. Page, Hyde Park, Vt.										
No Filler Fertilizer	3.	12	11	..	Yes	Passed	.4	.6	.4	..
Parmenter & Polsey Fertilizer Company, 41 North Market St., Boston, Mass.										
Corn and Grain Fertilizer	0.82	13	10	..	Yes	Not passed (34)	.7	.3	.8	..
Potato Fertilizer	2.05	11	10	..	Yes	Not passed (35)	.8	.2	.7	..
Reading Bone Fertilizer Company, Reading, Pa.										
Dissolved Animal Matter	0.82	11	10	..	? (36)	Passed	.8	.2	.8	..
Reading All Crop Special	1.64	11	10	..	Yes	Passed	.7	.3	.8	..
Reading Prize Winner	2.46	10	9	..	No (37)	Passed	.8	.2	.7	..
Reading Special Grain and Grass Producer	0.82	8	7	..	Yes	Passed	.6	.4	.4	..
Reading Special Potato and Tobacco Manure	0.82	13	12	..	Yes	Passed	.7	.3	.9	..
Rogers and Hubbard Company, Middletown, Conn.										
All Soils—All Crops Phosphate	3.3	13.5	12.5	..	Yes	Passed	.8	.2	.8	..
"Bone Base" Fertilizer for Oats and Top Dressing	6	12	6	..	Yes	Passed	.8	.2	.0	..
"Bone Base" Soluble Corn and General Crops Manure	2.5	12	10	..	No (38)	Passed	.7	.3	.5	..
"Bone Base" Soluble Potato Manure	4.25	13	10	2	No (39)	Passed	.7	.3	.6	CS
Complete Phosphate	1	8	7.5	..	Yes	Passed	.6	.4	.9	..
Potato Phosphate	2	15	14	..	Yes	Passed	.7	.3	.9	..
F. S. Royster Guano Company, 1604-1614 Munsey Building, Baltimore, Md.										
C. B. Fish Ammoniated Phosphate	1.64	8.5	8	..	No (40)	Passed	.6	.4	.9	..
Dreadnaught Guano	1.65	8.5	8	2	Yes	Passed	.7	.3	.9	CS
Fish and Potash Guano	1.65	8.5	8	1	No (42)	Not passed (42)	.6	.4	.9	C
Landmark Ammoniated Phosphate	3.29	10.5	10	..	Yes	Passed	.6	.4	.9	..
Penguin Ammoniated Phosphate	1.65	10.5	10	..	Yes	Passed	.7	.3	.9	..
Sanderson Fertilizer and Chemical Company, New Haven, Conn.										
Atlantic Coast Bone, Fish and Potash, 1916	1.65	10	9	1	Yes	Not Passed (44)	.5	.5	.7	C
Corn Superphosphate, 1916	1.65	11	10	1	Yes (45)	Passed	.5	.5	.6	C
Potato Manure, 1916	2.06	9	8	1	Yes	Passed	.6	.4	.7	C

CONCERNING DEFICIENCIES

AMERICAN AGRICULTURAL CHEMICAL COMPANY

(1) *Extra Quality Potato Manure.* Nitrogen 0.4% short of guaranty, but available phosphoric acid 0.9% in excess of guaranty. *No shortage in total amount of plant food.*

(1a) *Grass and Oats Fertilizer.* Available phosphoric acid 0.3% short of guaranty, but potash 0.1% in excess. *Shortage of plant food 2%.*

(2) *High Grade Fertilizer, 1916.* Available phosphoric acid 1% short of guaranty, but potash 2% in excess of guaranty. In all probability an error in shipment or a substitution of the 2/8/3 grade. The potash excess far outweighs the available phosphoric acid deficiency; hence there is *no shortage in total amount of plant food.*

(3) *Bradley's Potato Manure, 1916.* Nitrogen 0.2% and available phosphoric acid 0.3% short of guaranty, but potash 0.5% in excess of guaranty. *No shortage in total amount of plant food.*

(4) *Bradley's Special Corn Phosphate without Potash.* Nitrogen 0.3% and available phosphoric acid 0.2% short of guaranty. *Shortage in total plant food 5%.*

(5) *Bradley's Special Eclipse Phosphate.* Nitrogen 0.1% and potash 0.2% short of guaranty, but available phosphoric acid 0.2% in excess of guaranty. *No shortage in total plant food.*

(6) *Crocker's Potato, Hop and Tobacco Fertilizer, 1916.* Nitrogen 0.4% and available phosphoric acid 2.5% short of guaranty; potash 0.2% in excess of guaranty. *Shortage in total plant food 2%.* It seems highly probable that some error in shipment occurred in this case, although the writer is at a loss as to the identity of the substitution. The company is taking steps looking toward an adjustment of this error.

ARMOUR FERTILIZER WORKS

(7) (8) (9) *Grain Grower* 2/8/2; *Crop Grower* 1/8/2 *Fertilizer; Wheat, Corn and Oats Special* 1/7/1. Contain respectively 59, 53 and 56 percents of their total nitrogen contents in relatively unavailable forms.

BURLINGTON RENDERING COMPANY

(10) *Animal Fertilizer* 3/10. Nitrogen 0.3% short of guaranty.

but available phosphoric acid 0.1% in excess of guaranty. *Shortage in total plant food 1%.*

(11) *Burlington Fertilizer* 1/10. Contains 57% of its total nitrogen contents in relatively unavailable forms.

COE-MORTIMER COMPANY

(12) *Original Ammoniated Dissolved Phosphate, 1916.* Available phosphoric acid 0.4% short of guaranty. *Shortage in total plant food 3%.*

(13) *Standard Potato Fertilizer, 1916.* Available phosphoric acid 0.4% short of guaranty, but nitrogen 0.2% and potash 0.3% in excess of guaranty. *No shortage in total plant food.*

ESSEX FERTILIZER COMPANY

(14) (16) (17) *Bone Fertilizer; Grain, Grass and Potato Fertilizer; Two-Eight-Four.* Contain respectively 51, 51 and 40 percents of their total nitrogen contents in relatively unavailable forms.

(15) *Fish Fertilizer.* Nitrogen 0.2% and available phosphoric acid 0.4% short of guaranty. *Shortage of total plant food 5%.*

(17) *Two-Eight-Four.* Nitrogen 0.2%, available phosphoric acid 0.2% and potash 1.9% short of guaranty. *Shortage of total plant food 17%.* In all probability an error in shipment occurred, substituting the 2/8/2 grade for the 2/8/4. The company is taking steps looking toward an adjustment of this error. (Note the statement above as to unavailable nitrogen contents.)

INTERNATIONAL AGRICULTURAL CORPORATION—BUFFALO FERTILIZER WORKS

(18) *General Favorite.* Available phosphoric acid 0.3% and potash 0.5% short of guaranty. *Shortage of total plant food 8%.*

(19) *Tip Top.* Contains 40% of its total nitrogen contents in relatively unavailable forms.

LISTERS' AGRICULTURAL CHEMICAL WORKS

(20) (21) (22) *Grain and Grass Fertilizer, 1916; One-Eight-Two Fertilizer; Revised Vermont Corn and Potato Fertilizer.* Contain respectively 44, 67 and 64 percents of their total nitrogen contents in relatively unavailable forms.

(21) *One-Eight-Two Fertilizer.* Potash 0.7% short of guaranty, but nitrogen 0.2% and available phosphoric acid 1.0% in excess of guaranty. *No shortage in total plant food.* (Note the statement above as to unavailable nitrogen contents.)

(22) *Revised Vermont Corn and Potato Fertilizer.* Available phosphoric acid 0.3% short of guaranty, but nitrogen 0.2% and potash 0.2% in excess of guaranty. *No shortage in total plant food.* (Note the statement above as to unavailable nitrogen contents.)

LOWELL FERTILIZER COMPANY

(23) *Animal Brand.* Available phosphoric acid 0.9% short of guaranty. *Shortage in total plant food 7%.*

(24) (25) (27) *Bone Fertilizer; Dissolved Bone Fertilizer; Sterling Phosphate.* Contain respectively 48, 52 and 47 percents of their total nitrogen contents in relatively unavailable forms.

NATIONAL FERTILIZER COMPANY

(28) *Universal Grain and Potato Fertilizer.* Available phosphoric acid 0.5% short of guaranty but nitrogen 0.2% and potash 0.5% in excess of guaranty. *No shortage in total plant food.*

NEW ENGLAND FERTILIZER COMPANY

(29) (31) (32) *Corn and Grain Fertilizer; Standard Phosphate; Two-Eight-Four.* Contain respectively 45, 50 and 49 percents of their total nitrogen contents in relatively unavailable forms.

(30) *Potato Fertilizer.* Nitrogen 0.1% short of guaranty, but available phosphoric acid 0.3% in excess of guaranty. *No shortage in total plant food.*

NITRATE AGENCIES COMPANY

(33) *3/10 Corn and Potato.* Nitrogen 0.6% short of guaranty, but available phosphoric acid 0.4% in excess of guaranty. *Shortage in total plant food 2%.*

PARMENTER & POLSEY FERTILIZER COMPANY

(34) (35) *Corn and Grain Fertilizer; Potato Fertilizer.* Contain respectively 44 and 47 percents of the total nitrogen contents in relatively unavailable forms.

READING BONE FERTILIZER COMPANY

(36) *Dissolved Animal Matter.* Available phosphoric acid 0.3% short of guaranty, but nitrogen 0.4% in excess of guaranty. *No shortage in total plant food.*

(37) *Prize Winner.* Nitrogen 0.5% short of guaranty, but available phosphoric acid 0.1% in excess of guaranty. *Shortage in total plant food 3%.*

ROGERS & HUBBARD COMPANY

(38) *"Bone Base" Soluble Corn and General Crops Manure.* Nitrogen 0.1% and available phosphoric acid 0.2% short of guaranty. *Shortage of plant food 2%.*

(39) *"Bone Base" Soluble Potato Manure.* Available phosphoric acid 1.1% short of guaranty, but nitrogen 0.4% and potash 0.3% in excess of guaranty. *Shortage in total plant food 3%.*

F. S. ROYSTER GUANO COMPANY

(40) *C. B. Fish Ammoniated Phosphate.* Nitrogen 0.5% and available phosphoric acid 0.7% short of guaranty. *Shortage in total plant food 12%.*

(42) *Fish and Potash Guano.* Nitrogen 0.3% and potash 0.4% short of guaranty, but available phosphoric acid 1.1% in excess of guaranty. *No shortage in total plant food contents.*

(42) *Fish and Potash Guano.* Contains 42% of its total nitrogen content in relatively unavailable forms.

SANDERSON FERTILIZER & CHEMICAL COMPANY

(44) *Atlantic Coast Bone, Fish and Potash, 1916.* Contains 51% of its total nitrogen contents in relatively unavailable forms.

(45) *Corn Superphosphate, 1916.* Available phosphoric acid 2% short of guaranty but nitrogen 1.6% and potash 0.3% in excess of guaranty. *No shortage of total plant food.* In all probability an error in shipment occurred.

DISCUSSION OF THE RESULTS OF INSPECTION

Quantity of plant food. Fertilizers sold in Vermont in the spring of 1919—if one may judge by the results of inspection—as a whole

were not up to the usual grade. There were 307 guaranties made, 37 of which, or one in eight, were not maintained. However, of these 37 deficiencies, only 11, or one in 28, were in excess of 0.5%. On the other hand, when the average nitrogen guaranty is 2.5% and the average potash guaranty 1.5%, it ought to be easy to shoot within 20% or 33% of that mark. Thirty brands were in trouble, or 23% of the entire number. This is a larger percentage than has been found during the past ten years. In 16 of the 30 brands there was no shortage of total plant food, in seven others the deficiency was 3% or less, in four others it ranged from 5 to 8% and in three cases the goods were 12, 17 and 21 percents deficient. In these latter cases the presumption is that misshipments occurred. The companies have been notified and in all cases have promised to take up the matter and to make proper adjustments. In this connection, it should not be forgotten that the fertilizer trade has been severely handicapped during the past two years.

The manufacturers as usual, and very properly, give on the whole little more than they guarantee to give.

The average fertilizer sold in Vermont in 1919 contained about 2½% of nitrogen, 10% total and 9½% available phosphoric acid. Forty-nine brands, or about one in three, contained potash. Thirty were guaranteed to carry only 1%, an almost negligible quantity; 11, 2%; five, 3%; and three, 4%.

Quality of plant food. For the first time in 25 years the information which heretofore has been vouchsafed as to the nitrate and of ammoniacal nitrogen present in the several goods can not be furnished. The situation as to availability of organic nitrogen is the worst ever. No less than 21 brands, or one in 6, are listed as containing what seem to be undue amounts of unavailable organic nitrogen. It probably is true that many manufacturers have been put to it during recent years to get organic nitrogen in quantities sufficient to meet their needs; but whether farmers can afford to pay the prices asked for nitrogen if the material furnished is but slowly available to crop growth is a question they should answer for themselves. Attention is called to the specific statements on pages 10-13.

The proportions of phosphoric acid sold in available form vary about as usual.

A study of the brands is interesting. There were 145 licensed, but at best there were only 45 grades differing in the least as to composition and practically less than two-thirds that number.

Speaking broadly and using ammonia figures in lieu of nitrogen for the sake of simplicity, the grades which really seemed to constitute practically all the sales in Vermont were:

Number of brands	Ammonia	Available phosphoric acid	Potash
17	1	7-10	0
4	1½	10-12	0
23	2	10	0
4	2½	10	0
18	3	9-11	0
4	3½	10	0
12	4	10	0
5	5	8-10	0
9	Miscellaneous		
11	1-1½	7-10	1
13	2-2½	8-10	1
5	3	9	1
3	4	9-10	1
3	1	8	2
4	2	8	2
3	2	8	3
2	3	8	3
3	Miscellaneous		
2	..	10-12	2
145			

It seems quite safe to say that 95%, probably 98%, of the trade in mixed goods was confined to the 17 grades enumerated above. It is also perfectly safe to say that most needs would be met by the sale of not to exceed 10 grades.

CONCERNING THE COST OF COMMERCIAL FERTILIZERS IN VERMONT IN 1919

A considerable amount of data as to retail prices secured leads the writer to conclude that the following figures are fairly representative of the time-prices of goods sold in Vermont in 1919.

1/10 $36.	1/10/1 $40.	1/8/2 $46.		
2/10 43.	2/10/1 46.	2/8/2 53.	2/8/3 $61.	2/8/4 $67.
3/10 50.	3/9/1 51.			
4/10 55.		4/8/2 62.		4/8/4 76.

Now acid phosphate was sold at retail in several parts of Vermont at $32 to $34 and government nitrate was offered for less than $90. Each contained 16 percent of available plant food or 320 pounds per ton. A pound of available phosphoric acid cost, delivered, about 10 cts. a pound; a pound of nitrate nitrogen—as good as any and

better than many forms found in commercial fertilizers—cost less than 30 cts. delivered. Let us note what nitrogen cost in commercial fertilizers, calculating the available phosphoric acid at the price it was selling for at retail in Vermont in 1919.

1/10 grade 10% = 200 lbs. 200 × $0.10 = $20.

$36 — $20 = $16. 1% ammonia = 0.82% nitrogen = 16.4 lbs. nitrogen for $16 or 97.6 cts. a lb.

2/10 grade 32.8 lbs. nitrogen for $23 or 70.1 cts. a lb.

3/10 grade 49.2 lbs. nitrogen for $30 or 61 cts. a lb.

4/10 grade 65.6 lbs. nitrogen for $35 or 53.4 cts. a lb.

Potash seemed to cost at retail in Vermont in mixed goods somewhere from 25 to 30 cts. a pound, if one may judge by the above prices which, however, it is only fair to say were widely varient at different locations.

Now the University was in the market last spring to buy plant food. It bought crude stock, unmixed ingredients, and paid cash, as any farmer with ready money or good credit might have done. It paid for nitrogen in two forms, 33.3 and 37.4 cts a pound, which compare favorably with 53.4 to 97.6 cts. a pound; it paid 7.8 cts. a pound for available phosphoric acid, which is somewhat less than 10 cts.; and it bought no potash whatsover, because it was not thought that a new dollar in crop growth would be likely to replace an old one spent for potash.

Farmers who bought cooperatively through farmers' exchanges in 1919 as in previous years bought at a considerable saving as compared with the usual methods of purchase.

The average fertilizer sold in all probability for about $46, an advance of nearly 40% over the prices asked during 1915-17. The situation at this writing does not look bright for material reduction in prices during the coming year.

FEEDING STUFFS INSPECTION

The sampling agents of the Station visited 47 cities, towns and villages in Vermont in April and May, 1919, and drew 436 samples from dealers' stocks, representing about 275 brands of goods which either are subject to or exempt from the necessity of guaranty. The samples have been examined chemically for protein only.

The law seems fairly well observed at present. In a few cases, particularly when mixtures are locally made in a small way by Vermont

dealers, the packages do not declare their contents in terms of ingredients as is now required by law. Unguaranteed goods are infrequent at the present time and overguaranties are not as common as once they were; but overstatements in advertising still occur.

The following condensed statements set forth the facts as to protein guaranty maintenance as determined in the present inspection. Within groups, the order of statement is alphabetical by names of manufacturers or jobbers. Manufacturers' or jobbers' names and addresses are printed in SMALL CAPITALS, brand names in *italics*, guaranties in figures in parenthesis following the brand name. The deficiency in protein content, if any, is stated following the guaranty in *italics*.

COTTONSEED MEALS

PROTEIN GUARANTIES FULFILLED

BUCKEYE COTTON OIL CO., CINCINNATI, O., *Buckeye Good* (36). COTTONSEED PRODUCTS CO., LOUISVILLE, KY., *Good* (36). HUMPHRIES, GODWIN CO., MEMPHIS, TENN., *Danish* (36). LYLE & LYLE, HUNTSVILLE, ALA., *Economy* (36). (This brand, carrying the precise same guaranty as to its protein, fat and fiber contents as other brands listed in this paragraph, some of which are denominated as "good," frankly proclaims itself on the tag to be a "cottonseed feed made from cottonseed meal and cottonseed hulls." The writer commends this candid statement.) C. S. MONTGOMERY & CO., MEMPHIS, TENN.; *Star* (36). J. E. SOPER CO., BOSTON, MASS., *Puritan* (36).

PROTEIN GUARANTIES NOT FULFILLED

TAYLOR COMMISSION CO., MEMPHIS, TENN., *Good* (guaranty 36, analysis 35.1). UNION SEED & FERTILIZER CO., MONTGOMERY, ALA., *Surety* (guaranty 36, analysis 34.4).

One sample should be especially mentioned, namely, a goods offered by A. F. Hammond, of Pawlet on May 6. The bags carried two tags, one of which read as follows: "100 lbs. gross Low Grade Cottonseed Meal, guaranteed 5.76% nitrogen. Manufactured by Grantville Cotton Oil Co., Grantville, Ga.; Cottonseed Meal Registered Georgia, 1918, J. J. Brown, Com. Agl." (*sic.*). Mr. Hammond stated to the sampling agent that he was dissatisfied with the stock, that proper guaranty tags were not affixed and that the parties from whom he had bought sent "some" to put on the bags. One of these reads (in part) "Bartlett's Farmer Brand 'Straight' Cottonseed Meal, Protein 36%, The J. E. Bartlett Co., Sales Office, Jackson, Mich." As a matter of fact, this lot contained 32.5% protein. This case has been reported to the federal authorities.

LINSEED MEALS

PROTEIN GUARANTIES FULFILLED

AMERICAN LINSEED CO., BUFFALO, N. Y., *Old process* (34). ARCHER-DANIELS LINSEED CO., BUFFALO, N. Y., *Pure old process ground oil cake* (33). ELMORE MILLING CO., ONEONTA, N. Y., *Old process linseed meal, old process screening oil feed* (33). SPENCER KELLOGG & SONS, BUFFALO, N. Y., UNDERCLIFF, N. J., *Pure old process oil meal* (33). KELLOGGS & MILLER, AMSTERDAM, N. Y., *Pure old process oil meal* (31).

GLUTEN FEEDS

PROTEIN GUARANTIES FULFILLED

CLINTON SUGAR REFINING CO., CLINTON, IOWA, *Clinton* (23). CORN PRODUCTS REFINING CO., NEW YORK, N. Y., *Buffalo* (23). A. E. STALEY CO., DECATUR, ILL., *Staley's* (20).

PROTEIN GUARANTY NOT FULFILLED

AMERICAN MAIZE PRODUCTS CO., NEW YORK, N. Y., *Cream of Corn* (guaranty 23, analysis 22.4).

CORN GERM MEAL

PROTEIN GUARANTY FULFILLED

AMERICAN HOMINY CO., INDIANAPOLIS, IND., *Homcoline feed* (17).

BREWERS' DRIED GRAINS

PROTEIN GUARANTIES FULFILLED

ANHEUSER-BUSCH BREWING ASSOCIATION, ST. LOUIS, MO., *Steam dried* (22). WESTERN GRAIN & FEED CO., CHICAGO, ILL., ——— (25).

PROTEIN GUARANTIES NOT FULFILLED

FLEISCHMANN CO., CHICAGO, ILL., *Fleischmann's* (guaranty 19, analysis 16.8). FLEISCHMANN CO., CHICAGO, ILL., *Fleischmann's* (guaranty 16, analysis 14). GRAIN PRODUCTS SALES CO., NEW YORK, N. Y., *Columbia Corn Distillers' Grains* (guaranty 30, analysis 27.2).

PEANUT FEEDS

PROTEIN GUARANTIES FULFILLED

HUMPHREYS, GODWIN CO., MEMPHIS, TENN., *Liberty* (30). PIONEER PEANUT OIL CO., ABBEVILLE, ALA., *Pioneer Peanut Meal Feed*, composed of whole nuts with oil extracted (31.25). SOUTHERN COTTON OIL CO., DOTHAN, ALA., *Socoa* (36). LYLE & LYLE, HUNTVILLE, ALA., *Alaga unhulled peanut oil feed*, made of peanut meal and hulls (34).

VELVET BEAN FEED

PROTEIN GUARANTY FULFILLED

HUMPHREYS, GODWIN CO., MEMPHIS, TENN., *Duzesta* (17).

WHEAT OFFALS—BRAN

PROTEIN GUARANTIES FULFILLED

E. W. BAILEY & CO., MONTPELIER, VT., *Ball* (15). CENTRAL DAKOTA MILLING CO., ARLINGTON, S. DAK., *C. D. M.* (15). COMMANDER MILLING CO., MINNEAPOLIS, MINN., *Commander* (12). COMMERCIAL MILLING CO., DETROIT, MICH., ——— (14.5). FEDERAL MILLING CO., LOCKPORT, N. Y., *Lucky* (13). LYONS MILLING CO., LYONS, KAN., ——— (15). MARSHALL MILLING CO., MARSHALL, MINN., ——— (14.5). NEW PRAGUE FLOURING MILL CO., NEW PRAGUE, MINN., *Seal of Minnesota* (13). NIAGARA FALLS MILLING CO., NIAGARA FALLS, N. Y., *Choice* (12). OGDENSBURG ROLLER MILLS CO., OGDENSBURG, N. Y., *Choice* (14). PILLSBURY FLOUR MILLS CO., MINNE-

APOLIS, MINN., *Pillsbury* (13). RED WING MILLING CO., RED WING, MINN., *Bixota* (13.6). ROYAL MILLING CO., GREAT FALLS, MONT., *Royal* (15). RUSSELL-MILLER MILLING CO., MINNEAPOLIS, MINN., *Occident* (15). RUSSELL-MILLER MILLING CO., MINNEAPOLIS, MINN., ———— (13). ST. PAUL MILLING CO., ST. PAUL, MINN., *Koma* (14). F. W. STOCK & SONS, HILLSDALE, MICH., ———— (14). DAVID STOTT FLOUR MILLS, INC., DETROIT, MICH., *Spring Wheat* (14). THOMPSON MILLING CO., LOCKPORT, N. Y., *Angelus* (13). TOPEKA FLOUR MILLING CO., TOPEKA, KAN., ———— (14.5). VOIGHT MILLING CO., GRAND RAPIDS, MICH., *Crescent* (14). WASHBURN-CROSBY CO., MINNEAPOLIS, MINN., *Washburn-Crosby* (13). WEBER-FREEMAN FLOUR MILLING CORP., SALINA, KAN., ———— (14.5). WESTERN FLOUR MILL CO., DAVENPORT, IA., *Blackhawk* (13). YERXA, ANDREWS, THURSTON CO., MINNEAPOLIS, MINN., *Nokomas* (12).

UNGUARANTEED

BILL, BELL & CO., OGDENSBURG, N. Y., ———— (analysis 14). FUHRER-FORD MILL. CO., VERNON, OHIO, *Winter Wheat* (analysis 16.8).

(NOTE: Guaranties of wheat, rye and barley offals are not required by the Vermont law.)

WHEAT OFFALS—MIDDLINGS

PROTEIN GUARANTIES FULFILLED

ATLAS WHEAT FLOUR MILLS CO., MINNEAPOLIS, MINN., *Atlas Wheat Flour* (14). BIG DIAMOND MILLS CO., MINNEAPOLIS, MINN., *Big Diamond Wheat Flour* (16). CENTURY MILLS, MINNEAPOLIS, MINN., *Wheat Standard* (14). COMMANDER MILLING CO., MINNEAPOLIS, MINN., *Commander* (15). B. A. ECKHART MILLING CO., CHICAGO, ILL. ———— (14.5). HUBBARD MILLING CO., MANKATO, MINN., *Standard Fine* (15). KEHLOR FLOUR MILLS CO., ST. LOUIS, MO., *Rex* (16). MARSHALL MILLING CO., MARSHALL, MINN., *Wheat Shorts* (15). MONTANA FLOUR MILLS CO., ————, *Montana* (15.7). NIAGARA FALLS MILLING CO., NIAGARA FALLS, N. Y., *Choice* (14). NORTHWESTERN CONSOLIDATED MILLING CO., MINNEAPOLIS, MINN., *Standard* (15). NORTHWESTERN CONSOLIDATED MILLING CO., MINNEAPOLIS, MINN., *Wheat Flours* (15.5). OSCEOLA MILL & ELEVATOR CO., FAIRMONT, N. DAK., *Standard Wheat* (14). PILLSBURY FLOUR MILLS CO., MINNEAPOLIS, MINN., *Standard* (14). PILLSBURY FLOUR MILLS CO., MINNEAPOLIS, MINN., *Pillsbury's XX Daisy Red Dog* (16). PILLSBURY FLOUR MILLS CO., MINNEAPOLIS, MINN., *Pillsbury's A War Stock* (15). RED WING MILLING CO., RED WING, MINN., *Bixota* (15.7). RUSSELL-MILLER MILLING CO., MINNEAPOLIS, MINN., *Alta Pure* (15). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore* (14.5). F. W. STOCK & SONS, HILLSDALE, MICH., *Flour* (16). DAVID STOTT FLOUR MILLS, INC., DETROIT, MICH., *Climax* (16). DAVID STOTT FLOUR MILLS, INC., DETROIT, MICH., *Pennant* (15). STOKES MILLING CO., WATERTOWN, S. DAK., *Standard Shorts* (16). TOPEKA FLOUR MILLING CO., TOPEKA, KAN., *Standard Wheat Shorts* (14.5). VALLEY CITY MILLING CO., GRAND RAPIDS, MICH., *Rowena* (15). VALLEY CITY MILLING CO., GRAND RAPIDS, MICH., *Rowena* (16.5). WASHBURN-CROSBY CO., MINNEAPOLIS, MINN., *Wheat Standard* (14). WEBER-FREEMAN FLOUR MILLING CORP., SALINA, KAN., *Shorts* (16).

UNGUARANTEED

E. W. BAILEY & CO., MONTPELIER, VT., *Flour*, analysis (15.7). OGDENSBURG ROLLER MILLS CO., OGDENSBURG, N. Y., *Germ*, analysis (16.7).

(NOTE: Guaranties of wheat, rye and barley offals are not required by the Vermont law.)

WHEAT OFFALS—MIXED FEEDS

PROTEIN GUARANTIES FULFILLED

ALLEN & WHEELER CO., TROY, OHIO, *Trojan Pure* (14.5). E. W. BAILEY & CO., MONTPELIER, VT., *Fancy* (15). BILL, BELL & CO., OGDENSBURG, N. Y., *Wise King* (15). E. CROSBY & CO., BRATTLEBORO, VT., *Crosby's Fancy* (16). FEDERAL MILLING CO., LOCKPORT, N. Y., *Dairy Maid* (12). FEDERAL MILLING CO., LOCKPORT, N. Y., *Dairy Maid* (12). FEDERAL MILLING CO., LOCKPORT, N. Y., *Lucky* (14). GARLAND MILLING CO., GREENSBURG, IND., *Garland* (16). GRAFTON ROLLER MILLS CO., GRAFTON, N. DAK., *Improved Grafton* (14). J. H. HEWITT, SOUTH ROYALTON, VT., *Our* (15). E. T. & H. K. IDE, ST. JOHNSBURY, VT., *Ideal Fancy* (15). A. H. MCLEOD MILLING CO., ST. JOHNSBURY, VT., *Brooks' Fancy* (16). NATIONAL MILLING CO., TOLEDO, OHIO, *Osota* (15). NORTHWESTERN CONSOLIDATED MILLING CO., MINNEAPOLIS, MINN., *Comet XXX Pure* (16.5). PILLSBURY FLOUR MILLS CO., MINNEAPOLIS, MINN., *Pillsbury's Fancy* (14). ROYAL MILLING CO., GREAT FALLS, MONT., *Royal* (15). RUSSELL-MILLER MILLING CO., MINNEAPOLIS, MINN., *Occident* (15). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore* (15). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Hygrade* (16). SHEFFIELD-KING MILLING CO., MINNEAPOLIS, MINN., *Gold Mine* (15). SPARKS MILLING CO., ALTON, ILL., *Try Me* (16). F. W. STOCK & SONS, HILLSDALE, MICH., *Monarch Fancy* (16). DAVID STOTT FLOUR MILLS, INC., DETROIT, MICH., *Stott's Honest* (15.5). VALIER & SPIES MILLING CO., ST. LOUIS, MO., *Valier's* (15). VALLEY CITY MILLING CO., GRAND RAPIDS, MICH., *Rowena* (15). VALLEY CITY MILLING CO., GRAND RAPIDS, MICH., *Farmers' Favorite* (14.5). VOIGHT MILLING CO., GRAND RAPIDS, MICH., *Voight's Cow* (16). WAGGONER-GATES MILLING CO., INDEPENDENCE, MO., *Soft Wheat* (15).

WHEAT OFFALS—RED DOG FLOUR

PROTEIN GUARANTIES FULFILLED

RED WING MILLING CO., RED WING, MINN., *Bixota* (15). WASHBURN-CROSBY CO., MINNEAPOLIS, MINN., *Pure Wheat Adrain* (16).

UNGUARANTEED

RUSSELL-MILLER CO., MINNEAPOLIS, MINN., *Low Grade Tekoe*, analysis 19.5.

(NOTE: Guaranties of wheat, rye and barley offals are not required by the Vermont law.)

WHEAT OFFALS—SCREENINGS

CENTURY MILLING CO., MINNEAPOLIS, MINN., *Jersey Feed* (ground screenings) (13).

(NOTE: Fully half of the guaranty statements on the bran, middlings and mixed feed bags declared the presence of screenings. Usually—but not always—the claim was made that these were "ground" and that the proportion did not exceed the "mill run." Buyers of wheat offals should note the facts as stated by manufacturers in making their choices).

RYE OFFALS—MIDDLINGS

PROTEIN GUARANTIES FULFILLED

ALBERT LEA MILLS, ALBERT LEA, MINN., ———— (15). NORTHLAND RYE MILLING CO., MINNEAPOLIS, MINN., *Northland* (15.5). PILLSBURY FLOUR MILLS CO., MINNEAPOLIS, MINN., *Pillsbury's* (15).

RYE OFFALS—FEEDS

PROTEIN GUARANTIES FULFILLED

BOUTWELL MILLING & GRAIN CO., TROY, N. Y., *Boutwell's* ("rye bran and middlings and any fine screenings that may be in rye grain") (13.5). KEHLOR

FLOUR MILLS CO., ST. LOUIS, MO., *Kehlor's* (16). STAR & CRESCENT MILLING CO., CHICAGO, ILL., ———— (14).

PROTEIN GUARANTY NOT FULFILLED

NATIONAL MILLING CO., TOLEDO, OHIO, ————, guaranty 16, analysis 10.3.

GROUND OATS

ARMOUR GRAIN CO., CHICAGO, ILL., *Feed Oatmeal*, guaranty 15, analysis 13.7. GREGORY GRAIN CO., BURLINGTON, VT., *White Rock*, analysis 11.9. H. A. SLAYTON & CO., MORRISVILLE, VT., analysis 11.8. OGDENSBURG ROLLER MILLS OGDENSBURG, N. Y., analysis 10.8. ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Hygrade*, analysis 11.4.

OAT HULLS

QUAKER OATS CO., PETERBOROUGH, CAN., ———— (5).

BARLEY PRODUCTS

NATIONAL MILLING CO., TOLEDO, OHIO, *Feed* (8). SHANE BROS. & WILSON CO., MINNEAPOLIS, MINN., *Feed*, guaranty 9.5, analysis 8.9. WASHBURN-CROSBY MILLING CO., MINNEAPOLIS, MINN., *Screenings*, guaranty 16, analysis, 11.2. E. W. BAILEY & CO., MONTPELIER, VT., *Ground Barley*, analysis 11.8.

CORN MEAL, ETC.

E. W. BAILEY & CO., MONTPELIER, VT., *Meal*, analysis 9.4. E. W. BAILEY & CO., MONTPELIER, VT., *Cracked Corn*, analysis 9.2. E. W. BAILEY & CO., MONTPELIER, VT., *Meal*, analysis 9. MT. MANSFIELD CREAMERY, STOWE, VT., analysis 8.8. H. A. SLAYTON & CO., MORRISVILLE, VT., ———— (9.7). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Hygrade recleaned yellow corn*, analysis 9.2. ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Hygrade roller corn meal*, analysis 8.2. WASHBURN-CROSBY CO., MINNEAPOLIS, MINN., *Corn Feed Meal*, analysis 8.

PROVENDERS

E. W. BAILEY & CO., MONTPELIER, VT., analysis 10.3. N. N. MORSE & CO., RANDOLPH, VT., analysis 11.4. OGDENSBURG ROLLER MILLS CO., OGDENSBURG, N. Y., analysis 10.3. GRADY CO., ST. ALBANS, VT., *No. 1*, analysis 10.1. C. WRIGHT, BELLOWS FALLS, VT., analysis 10.8.

HOMINY FEEDS

PROTEIN GUARANTIES FULFILLED

ARMOUR GRAIN CO., CHICAGO, ILL., ———— (10). BALLARD CORN MEAL CO., LOUISVILLE, KY., *Ballard's* (10.5). BALTIMORE PEARL HOMINY CO., BALTIMORE, MD., *Spring Garden* (10). CHAS. M. COX CO., BOSTON, MASS., *Paragon* (9.5). LOUISVILLE CEREAL MILLS CO., LOUISVILLE, KY., ———— (9.11). PATENT CEREALS CO., GENEVA, N. Y., ———— (10). PLYMOUTH MILLING CO., LE MARS, IOWA, *Plymouth Pure* (10). STANDARD CEREAL CO., CHILLICOTHE, OHIO, *Logan* (9).

PROTEIN GUARANTY NOT FULFILLED

PERIN BROS., CINCINNATI, OHIO, *Choice* (guaranty 10, analysis 9.6).

DRIED BEET PULP

LARROWE MILLING CO., DETROIT, MICH., ———— (8). MARITIME TRADING CORPORATION, NEW YORK, N. Y., ———— (8).

PROPRIETARY FEEDS—DAIRY

PROTEIN GUARANTIES FULFILLED

AMERICAN MILLING CO., PEORIA, ILL., *Amco* (25). ARMOUR GRAIN CO., CHICAGO, ILL., *Armour's* (22). BURLINGTON FLOUBING CO., WINOOSKI, VT., *H* (18). CHAPIN & CO., HAMMOND, IND., *Triangle* (21). CHAPIN & CO., HAMMOND, IND., *Unicorn* (26). DEWEY BROS. CO., BLANCHESTER, OHIO, *Dewey's Ready Ration* (25). ELMORE MILLING CO., ONEONTA, N. Y., *Elmore Milk Grains* (25). D. H. GRANDIN MILLING CO., JAMESTOWN, N. Y., *Twin-Six* (22). H. O. CO., BUFFALO, N. Y., *Algrane Milk* (14). J. H. HEWITT, SOUTH ROYALTON, VT., *Our Balanced Ration* (20). INTERNATIONAL SUGAR FEED CO., MINNEAPOLIS, MINN., *International Climax* (12). INTERNATIONAL SUGAR FEED CO., MINNEAPOLIS, MINN., *International Ready Ration* (20). LARROWE MILLING CO., DETROIT, MICH., *Big Six* (21). LARROWE MILLING CO., DETROIT, MICH., *Larrowe for Dairy Cows* (20). PARK & POLLARD CO., BOSTON, MASS., *Stevens' 44* (24). PURINA MILLS, ST. LOUIS, MO., *Cow Chow* (24). QUAKER OATS CO., CHICAGO, ILL., *Big Q* (21). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Farmers' Favorite* (25). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Paragon* (22). UBIKO MILLING CO., CINCINNATI, OHIO, *Ohio Union Grains* (24.5). VERMONT CEREAL CO., BURLINGTON, VT., *Waumbec Butter Fat Meal* (20). R. P. WEBSTER, BARTON, VT., *Ray's Ready Ration* (25).

PROTEIN GUARANTIES NOT FULFILLED

CHAS. M. COX CO., BOSTON, MASS., *Wirthmore Balanced Ration*, guaranty 25, analysis 23.6. E. CROSBY & CO., BRATTLEBORO, VT., *Crosby's Ready Ration*, guaranty 25, analysis 24.4. E. CROSBY & CO., BRATTLEBORO, VT., *Crosby's 1918 Dairy Ration*, guaranty 25, analysis 22.5. ALBERT DICKINSON CO., CHICAGO, ILL., *Dickinson's*, guaranty 24, analysis 23. ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore Balance Ration*, guaranty 25, analysis 24.

PROPRIETARY FEEDS—STOCK

PROTEIN GUARANTIES FULFILLED

AKRON FEED & MILLING CO., AKRON, OHIO, *Portage* (8). ARMOUR GRAIN CO., CHICAGO, ILL., *Armour* (12). E. W. BAILEY & CO., MONTPELIER, VT., *Bailey's Fancy* (15). CHAMPION PRODUCTS CORPORATION, COHLESKILL, N. Y., *Champion* (8). CLOVER LEAF MILLING CO., BUFFALO, N. Y., *Clover Leaf* (10). COMMERCIAL MILLING CO., DETROIT, MICH., *Henkel's Chop* (8.5). CHARLES M. COX CO., BOSTON, MASS., *Charlestock* (6). E. CROSBY & CO., BRATTLEBORO, VT., *Crosby's Special* (10). E. CROSBY & CO., BRATTLEBORO, VT., *Zenith* (8.5). D. H. GRANDIN MILLING CO., JAMESTOWN, N. Y., *Grandin's* (9). H-O CO., BUFFALO, N. Y., *New England* (9). J. H. HEWITT, SOUTH ROYALTON, VT., *Our* (8). E. T. & H. K. IDE, ST. JOHNSBURY, VT., *Ideal* (10). MARITIME TRADING CO., BUFFALO, N. Y., *Bull* (11). PARK & POLLARD CO., BOSTON, MASS., ———— (9). PURINA MILLS CO., BUFFALO, N. Y., *Purina-O-Molene* (9.7). PURITY OATS CO., DAVENPORT, IOWA, *Loyal* (10). PURITY OATS CO., DAVENPORT, IOWA, *Iowa* (10). QUAKER OATS CO., CHICAGO, ILL., *Schumaker's* (10). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore* (9).

PROTEIN GUARANTIES NOT FULFILLED

E. W. BAILEY & CO., MONTPELIER, VT., *Pennant*, guaranty 10, analysis 9.3. ACME-EVANS CO., INDIANAPOLIS, IND., *Acme*, guaranty 10, analysis 9.4.

PROPRIETARY FEEDS—HORSES

PROTEIN GUARANTIES FULFILLED

CORNO MILLS CO., ST. LOUIS, MO., *Corno Horse and Mule* (10).

PROTEIN GUARANTIES NOT FULFILLED

H-O CO., BUFFALO, N. Y., *Algrane*, guaranty 11, analysis 10.5

PROPRIETARY FEEDS—CALF

PROTEIN GUARANTIES FULFILLED

QUAKER OATS CO., CHICAGO, ILL., *Schumaker's* (18). BLATCHFORD'S CALF MEAL FACTORY, WAUKEGAN, ILL., *Blatchford's* (24). HALES & EDWARDS CO., CHICAGO, ILL., *Red Horn* (18).

PROPRIETARY FEEDS—SWINE

PROTEIN GUARANTIES FULFILLED

CHAPIN & CO., HAMMOND, IND., *Bicorn Hog* (17.5). CORN PRODUCTS REFINING CO., CHICAGO, ILL., *Diamond Hog* (18). PARK & POLLARD CO., BOSTON, MASS., *Go To It Hog Ration* (15.) ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore Pig* (18). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore Hog* (17).

PROPRIETARY FEEDS—POULTRY—MASHES

PROTEIN GUARANTIES FULFILLED

CHAS. M. COX CO., BOSTON, MASS., *Wirthmore* (20). E. CROSBY & CO., BRATTLEBORO, VT., *Egg Mash* (16). HALES & EDWARDS CO., CHICAGO, ILL., *Red Cloud* (15). J. H. HEWITT, SOUTH ROYALTON, VT., *Our Dry* (13). W. B. JOHNSON & SON, ESSEX JUNCTION, VT., *Dry* (16). PARK & POLLARD CO., BOSTON, MASS., *Lay or Bust* (18). PURITY OATS CO., DAVENPORT, IOWA, *Tom Boy* (15). QUAKER OATS CO., CHICAGO, ILL., *Ful-O-Pep Growing* (17). QUAKER OATS CO., CHICAGO, ILL., *Ful-O-Pep Dry* (20). ST. ALBANS GRAIN CO., ST. ALBANS, VT., *Wirthmore Fish & Scrap* (20).

PROPRIETARY FEEDS—POULTRY—SCRATCH FEEDS

PROTEIN GUARANTIES FULFILLED

AKRON FEED & MILLING CO., AKRON, OHIO, *Portage* (9). CHAS. M. COX CO., BOSTON, MASS., *Wirthmore* (10). E. CROSBY & CO., BRATTLEBORO, VT., *Fort Dummer* (10). ALBERT DICKINSON CO., CHICAGO, ILL., *Rival* (8.5). HALES & EDWARDS CO., CHICAGO, ILL., *Red Comb* (9). PARK & POLLARD CO., BOSTON, MASS., *Red Ribbon* (10). PURITY OATS CO., DAVENPORT, IOWA, *Tom Boy* (10). QUAKER OATS CO., CHICAGO, ILL., *Schumaker's* (10). ————, ————, *Pontiac* (10).

UNGUARANTEED

J. W. JONES & CO., BURLINGTON, VT., ————, analysis 10.9. R. H. MCEWEN MILLING CO., OGDENSBURG, N. Y., *Red Feather*, analysis 11.5.

PROPRIETARY FEEDS—POULTRY—CHICK

PROTEIN GUARANTIES FULFILLED

C. E. CONKEY CO., CLEVELAND, OHIO, *Conkey's Buttermilk Starting* (12). CHAS. M. COX CO., BOSTON, MASS., *Wirthmore Buttermilk Baby Chick* (13.5).

CHAS. M. COX CO., BOSTON, MASS., *Wirthmore Gritless* (11). ELMORE MILLING CO., ONEONTA, N. Y., *Elmore* (10). HALES & EDWARDS CO., CHICAGO, ILL., *Red Comb* (16). PARK & POLLARD CO., BOSTON, MASS., *Red Ribbon* (10). PARK & POLLARD CO., BOSTON, MASS., *Blue Ribbon* (10). PARK & POLLARD CO., BOSTON, MASS., *Baby Buster* (11). PURINA MILLS, ST. LOUIS, MO., *Purina* (10). QUAKER OATS CO., CHICAGO, ILL., *Schumaker's Little* (10).

PROPRIETARY FEEDS—POULTRY—MISCELLANEOUS

PROTEIN GUARANTIES FULFILLED

BLATCHFORD'S CALFMEAL FACTORY, WAUKEGAN, ILL., *Blatchford's Milk Substitute for Poultry* (20). E. CROSBY & CO., BRATTLEBORO, VT., *Crosby's Pure Poultry Food* (10). ALBERT DICKINSON CO., CHICAGO, ILL., *Globe Developing Feed* (10). HALES & EDWARDS CO., CHICAGO, ILL., *Red Comb Poultry Feed* (9). CARROLL S. PAGE, HYDE PARK, VT., *Page's Poultry Food* (24). PARK & POLLARD CO., BOSTON, MASS., *Growing Feed* (10).

PROTEIN GUARANTY NOT FULFILLED

GEO. L. HARDING, BINGHAMPTON, N. Y., *Harding's Uncle Sam Granulated Milk Albumen for Poultry*, guaranty 40, analysis 32.4.

PROPRIETARY FEEDS—MISCELLANY

(NOTE: The following goods are of a sort which seems to defy classification. at any rate according to the system employed in this bulletin.)

PROTEIN GUARANTIES FULFILLED

QUAKER OATS CO., CHICAGO, ILL., *Banner Feed* (screenings and ground corn) (8). QUAKER OATS CO., CHICAGO, ILL., *Buckeye Feed* (wheat mixed feed with ground screenings not exceeding mill run, and rye shorts) (15.5). ST. ALBANS GRAIN CO., ST. ALBANS VT., *Wargrade mixed feed* (wheat bran. rye, middlings—with ground screenings not to exceed mill run—and red dog) (13).

PROTEIN GUARANTIES NOT FULFILLED

INDIANA MILLING CO., TERRE HAUTE, IND., *Holstein Feed* (wheat bran with ground screenings not exceeding mill run and cob meal), guaranty 12. analysis, 11.4. A. H. MCLEOD MILLING CO., ST. JOHNSBURY, VT., *Green Mountain Mixed Feed* (dark rye flour, wheat bran and middlings), guaranty 16, analysis 14.5. QUAKER OATS CO., CHICAGO, ILL., *Vim Feed*, guaranty 5, analysis 4.8.

DISCUSSION OF THE RESULTS OF INSPECTION

Samples were taken representing 29 brands of the high protein by-products (cottonseed and linseed meals, gluten feeds, brewers' dried grains, peanut feeds), 41 samples of low protein products other than wheat offals (hominy feed, dried beet pulp, provenders, corn meals, ground oats, barley and rye products, etc.), 93 samples of wheat offals (brans, middlings, mixed feeds, red dog flour) and 111 samples of proprietary brands (ready mixed rations for dairy cows, horses, poultry, calves, swine and stock in general).

	Number of samples	Protein guaranties range from	Protein contents range from	Deficiencies	Unguaranteed
Cottonseed meals	9	36	42.5 to 32.5	3	0
Linseed meals	5	34 to 31	36.6 to 34.9	0	0
Gluten feeds, etc.	5	23 to 17	25.6 to 17.8	1	0
Brewers' dried grains	5	30 to 16	27.2 to 14	3	0
Peanut feeds	4	36 to 30	40.1 to 29.8	0	0
Velvet bean meal	1	17	16.7	0	0
Wheat offals	93	16.5 to 12	19.8 to 13.4	0	5
Wheat brans	27	15 to 12	18.4 to 13.4	0	2
Wheat middlings	31	16 to 14	19.8 to 15.4	0	2
Wheat mixed feeds	31	16.5 to 12	19.8 to 15.4	0	1
Red dog flours	3	16 to 15	19.3 to 18	0	0
Screenings	1	13	14.5	..	..
Hominy feeds	9	10.5 to 9.5	11.6 to 9.6	1	0
Dried beet pulp	2	8	8.6 to 8.1	0	0
Miscellaneous	30	..	17.1 to 6.1	..	..
Provender	5	..	11.4 to 10	..	..
Corn meal	8	..	9.4 to 8.1	..	..
Ground oats	5	..	13.7 to 10.8	..	..
Barley products	4	..	11.8 to 9	..	..
Rye products	7	16 to 13.5	17.1 to 10.3	..	..
Oat hulls	1	5	6.1	..	..
Proprietary feeds	111	40 to 6	48.3 to 8.8	8	3
Dairy	32	26 to 13.5	27.6 to 13.6	5	0
Stock	23	15 to 6	15.8 to 8.8	2	0
Horse	2	11 to 10	11.8 to 10.3	1	0
Calf	3	24 to 18	26.5 to 19.8	0	0
Swine	5	18 to 15	21.1 to 18	0	0
Poultry	39	40 to 8	48.3 to 10	0	3
Mashes	10	20 to 13	22.1 to 15.6	0	0
Scratch feeds	11	11 to 8.5	11.4 to 10.3	0	2
Chick feeds	10	6 to 10	16.9 to 10.5	0	0
General	8	40 to 9	48.3 to 10	0	1
Miscellaneous	7	16 to 8	17.6 to 11.4	0	0
Totals				16	*3

*Wheat offals need no guaranty statements.

The serious discrepancies are as follows:

Cottonseed Meal, bearing two tags; one of the Grantville Cotton Oil Co., Grantville, Ga., and one of the J. E. Bartlett Co. of Jackson, Mich., guaranteed 36% protein, containing 32.5%.

Brewers' Dried Grains. Fleischmann Co., Chicago, Ill., two lots guaranteed respectively 19 and 16 percents, carrying respectively 16.8 and 14 percents protein.

Distillers' Dried Grains. Grain Products Sales Co., New York, N. Y., Columbia Corn Distillers' Grains, guaranteed 30%, containing 27.2% protein.

E. Crosby & Co., Brattleboro, Vt. Crosby's 1918 Dairy Ration, guaranteed 25%, contained 22.5% protein.

E. W. Bailey & Co., Montpelier, Vt. Pennant Stock Feed, guaranteed 10%, contained 9.3% protein. The records of several past inspections indicate that this brand is quite apt to carry less protein than its guaranty statement would lead the buyer to expect.

Acme-Evans Co., Indianapolis, Ind. Acme Stock Feed, guaranteed 10%, analaysis 9.4% protein.

AGRICULTURAL SEED INSPECTION

The Station sampling agents visited about 40 Vermont towns and villages during May, 1919, and gathered about 200 samples of agricultural seed offered for sale in the open markets by local dealers as follows:

Alfalfa 9	Timothy 35	Rape 3
Barley 10	Blue grass 3	Rye 1
Clover, alsike 12	Buckwheat 1	Rye grass 1
Clover, red 14	Clover, white 1	Soy beans 1
Corn 39	Lawn grass 3	Sweet clover 1
Millet 14	Meadow fescue 2	Wheat 6
Oats 14	Orchard grass..... 1	
Redtop 10	Peas, field 4	

These samples were drawn in the official manner. Purity tests were made by the weight method and the germination tests were made according to the method employed by the Federal Department of Agriculture.

The notations in parenthesis, i. e. (14), refer to the comments on pages 31 to 32 under the head "Concerning Deficiencies."

Trade name	Wholesaler	Purity guaranty	Germination percent	Weed seeds per lb.
	ALFALFA			
————	Dickinson	99	84	90
Grimm	Lyman	*97.46* (1)	92	725
Honor	Stanford	99.25	92	1360
Honor	Stanford	99.5	96	0
————	Stanford	99.4	83	0
Eureka	Whit.-Eck.	99.75	95	90
Eureka	Whit.-Eck.	99.8	88	180
Pan-American	Whit.-Eck.	99	88	90
Pan-American	Whit.-Eck.	*99.16* (1)	88	900
	BARLEY			
Crow	Bailey	98 (2)	99	30
Six-Row	Dickinson	98	98	0
White Mountain	Holbrook	99	97	0
White Mountain	Holbrook	99	98	0
White Mountain	Holbrook	*99.83* (1)	96	0
Montana	St. Albans	99	98	0
Six-Row	Stanford	95	97	0
Six-Row	Stanford	99 (3)	98	30
————	Stanford	95	98	0
————	Whit.-Eck.	98	99	0
	ALSIKE CLOVER			
Imperial	Conklin	97.4	91	0
Queen	Dickinson	88.3	77	11800
Freedom	Doughton	97.05	92	1135
————	Gardinier	*98.2* (1)	88	450
Ace	Holbrook	95	81	5000
White Mountain	Holbrook	98.5	91	225
Anchor	Morehouse	99.5	97	0
Globe	Scott	*99.93* (1)	98	0
Queen	Slayton	88.3	76	6525
Honor	Stanford	97.75	96	675
————	Stanford	93.43	95	0
Pan-American	Whit.-Eck.	97	91	0
	RED CLOVER			
Chicago	Bailey	97	95	630
Queen	Dickinson	96	78	9450
————	Doughten	99	94	1620
Ace Mam.	Holbrook	98	91	1080
Ace Med.	Holbrook	*98.8* (1)	87	3510
White Mountain	Holbrook	99	94	990
White Mountain	Holbrook	99.5	94	270
White Mountain	Holbrook	99.75 (4)	98	540
————	Holbrook	99.5	31	630
Anchor	Morehouse	99.5	99	0
————	Scott	*99.7* (1)	86	720
A. R. C. Mam.	Stanford	98.8	94	270
Honor	Stanford	99.25	92	90
Eureka	Whit.-Eck.	*99.82* (1)	90	810

Trade name	Wholesaler	Purity guaranty	Germination percent	Weed seeds per lb.
	CORN			
U. S. Sel. 193	Aster	*99.39*	99	0
Canada Flint	Bailey	98	94	0
Longfellow	Bailey	98	92	0
Minn. King	Bailey	98 (5)	87	0
Sanford	Bailey	98	95	0
Early Yellow Canada	Breck	*99.7*	84	0
Burpee's	Burpee	100(1)	100	0
Burlington Dent	Champlain	95	97	0
Farmers' Friend	Champlain	*100*	100	0
Minn. 13	Champlain	95	92	0
Imperial Leaming	Conklin	99.04	84	0
Imperial Leaming	Conklin	98	72	0
Sanford Wht. Flint	Emerson	*100* (1)	94	0
Gold Nugget	Hawkins	*100*	32	0
Sanford	Holbrook	98	83	0
———	Holbrook	*100*	88	0
Pride of Michigan	Isbell	*100*	96	0
Early Mastodon	Michigan	90.95	98	0
King Early	Middlebrook	*100* (1)	100	0
Sanford White	Middlebrook	95	91	0
Pride North	Milford	*98.81*	73	0
King Philip	Northrup	*98.98* (1)	93	0
Crosby	Rice	*100*	88	0
8-Row Canada	Rice	*97.66*	93	0
Leaming	Rice	*97.4*	77	0
White Cory	Rice	*100*	87	0
Early Triumph	Stanford	99	91	0
Early Triumph	Stanford	97	96	0
Pride Nassau	Stanford	98	97	0
Pride North	Stanford	99	97	0
Rice F. Dent	Stanford	97	94	0
Sanford	Stanford	90	82	0
Sanford	Stanford	98	86	0
Imperial Leaming	Stanford	96	96	0
Longfellow	Whit.-Eck.	98	97	0
North King	Whit.-Eck.	99.5	88	0
Sanford	Whit.-Eck.	*99.6* (1)	99	0
———	Whit.-Eck.	98	86	0
White Flint	———	*100*	92	0
	MILLET			
Japanese	Conklin	97.2	96	3780
Japanese	Conklin	*97.6* (1)	84	4400
Japanese	Conklin	97	80	3740
Japanese	Dickinson	98	91	960
Japanese	Gardinier	*96.6* (1)	83	4050
Golden	Holbrook	*97.02* (1)	77	4320 (6)
Hungarian	Holbrook	*98.1* (1)	75	1440
Japanese	Landon	95.8	86	3870
Anchor	Morehouse	97	91	270
Hungarian	Stanford	97.94	45	540
Japanese	Stanford	95	88	1620
Hungarian	Whit.-Eck.	98	67	1440
Japanese	Whit.-Eck.	96 (7)	77	9530
Japanese	———	95	88	2340

Trade name	Wholesaler	Purity guaranty	Germination percent	Weed seeds per lb.
		OATS		
Mammoth	Bailey	99	98	60
———	Bailey	*98.87* (1)	97	15
Pennant	Bailey	99.5 (8)	100	0
———	Cox-Matherson	...	99	1500
Michigan	Cressy	*92.84* (9)	99	0
Heavyweight	Dibble	99	100	0
———	Gardnier	*99.61*	100	0
White Mountain	Holbrook	99	98	15
White Mountain	Holbrook	*99.77*	97	0
White	Quaker	*98.8*	95	75
———	Whit.-Eck.	98	99	15
White	Will.-Don.	*98.53*	95	15
Hygrade	St. Albans	99 (10)	98	75
———	———	85	100	15
		RED TOP		
———	Bailey	90	80	17240
Imperial	Conklin	93.5	62	2700
Imperial	Conklin	93	53	2250
B	Conklin	75	65	53550
A	Dickinson	90	41	11700
Recleaned	Gardinier	*95.6*	75	14400
White Mountain	Holbrook	95	56	10000
Ace Red	Holbrook	*92.7* (1)	56	34200
———	Holbrook	75	63	71230(11)
Fancy	Stanford	92.55	50	6300
		TIMOTHY		
———	Bailey	99.8	96	0
———	Bailey	99	94	0
———	Bailey	99.5 (12)	96	225
Pine Tree	Carv.-Dick.	95	96	0
Acme	Conklin	99.8	97	625
King	Conklin	99.6	95	225
King	Conklin	99.6	96	900
State	Conklin	99.7 (13)	97	450
Arrow	Conklin	99.1 (14)	96	450
Pyramid	Conklin	97.65 (15)	91	5850
Globe	Dickinson	98.8	98	0
Pine Tree	Dickinson	99.6	96	225
Pine Tree	Dickinson	99.5	97	225
Bison	Dickinson	98 (16)	93	2475
———	Gardinier	*99.76*	93	900
Globe	Holbrook	99.8	91	0
White Mountain	Holbrook	99.85	93	0
White Mountain	Holbrook	99.7	97	225
Pine Tree	Holbrook	99.5	92	450
Pine Tree	Landon	99	92	1125
Anchor	Morehouse	99.75	96	450
Stanford	Scott	*99.84* (1)	89	450
Globe	Slayton	*99.91*	100	225
Pine Tree	Slayton	*99.83*	98	225
Purity	Slayton	99.6	96	225
———	Small	99.47	16	2250
Liberty	Stanford	*99.87* (1)	90	1350

Trade name	Wholesaler	Purity guaranty	Germination percent	Weed seeds per lb.
Liberty	Stanford	99.5	95	900
Eureka	Whit.-Eck.	98	94	0
Eureka	Whit.-Eck.	95	95	225
Pan-American	Whit.-Eck.	99.5	92	225
Pan-American	Whit.-Eck	99.3	96	225
Gold Medal	Whit.-Eck.	99.75 (17)	97	3375
Gold Medal	Whit.-Eck.	99.75	94	0
Gold Medal	Whit.-Eck.	99.7	93	675
	MISCELLANEOUS			
Buckwheat	Whit.-Eck.	98	89	1125
English Rye Grass	Nung.-Dick.	*99.86* (1)	83	180
Ky. Blue Grass	Conklin	*96.1* (1)	1	1800
Ky. Blue Grass	Dickinson	82	2	4500
Ky. Blue Grass	Whit.-Eck.	*93.4*	1	3600
Lawn Grass	Field & Law	*96.36*	58	4050
Lawn Grass	Holbrook	*95* (1)	37	4050
Lawn Grass	Lovell	*98.1*	50	1350
Meadow Fescue	Nung.-Dick	*98.25* (1)	78	2025
Meadow Fescue	Robbins	*99.08*	17	0
Orchard Grass	Stanford	81	7	90
Field Peas	Holbrook	*98.53* (18)	90	27
Field Peas	Rice	*100* (18)	90	0
Field Peas	Whit.-Eck.	98	88	0
Field Peas	Whit.-Eck.	*96.72* (18)	94	0
Rape	Holbrook	*99.93* (1)	94	405
Rape	Stanford	90	99	202
Rape	Whit.-Eck.	*99.86* (1)	87	60
Spring Rye	Whit.-Eck.	98	95	45
Soy Bean	Holbrook	*94.58* (18)	76	0
Soy Bean	Whit.-Eck.	98.	98	0
Tim., Redtop, Clover	Whit.-Eck.	99.5 (19)	?	20700
Sweet Clover	Stanford	*99.38* (18)	52	270
Spring Wheat	Bailey	95	91	150
Spring Wheat	Holbrook	99.45	99	0
Spring Wheat	St. Albans	99	93	0
Wheat	Whit.-Eck.	99.5	96	15
Spring Wheat	Whit.-Eck.	98	100	30
Spring Wheat	Whit.-Eck.	98	98	0
White Clover	Holbrook	98.68	81	225
White Clover	Robbins	95	90	14850

DISCUSSION OF THE RESULTS OF INSPECTION

As has heretofore been found to be the case, the samples indicated that wholesalers as a rule have kept their promises. To be sure at times they have not promised much (e. g., 88.3% purity in alsike clover, 90% purity in corn, 85% purity in oats) but at least performance in the main has squared with promise.

The violations of the law consist of:

(1) *Failure to declare guaranties.* This amounts to practical nullification insofar as information touching guaranteed purity is con-

cerned, supplied to the purchaser of the usual amounts from broken packages. The writer has no means of knowing with certainty but has every reason to believe that local merchants, as a rule, fail to affix "a plainly written or printed statement," "conspicuously" to "every lot or parcel of agricultural seed of five pounds or over sold for seeding purposes" "clearly and truly certifying the name thereof and its minimum percentage of purity," etc.

Over 30 percent of the lots sampled by the station's agents bore no visible statement as to the purity of their contents. Almost invariably this information is furnished by the wholesaler, but very commonly the retailer pays no attention to and destroys it.

(2) *Failure to maintain guaranties.* More than 10 percent of the goods which were guaranteed were found to be deficient and 4 percent were seriously deficient. Especial attention is called to these cases:

E. W. Bailey & Co., Montpelier, Vt. Crow Barley; guaranteed 98% pure; found to be 96.45% pure and to contain 4.4% of oats.

Holbrook Grocery Co., Keene, N. H. White Mountain Red Clover; guaranteed 99.75% pure; found to be 93% pure and to contain 6.2% of timothy and redtop.

E. W. Conklin & Co., Binghampton, N. Y. Pyramid Timothy; guaranteed 97.65% pure; found to be 92.5% pure and to contain 7% of foreign seed, including much alsike and red clover.

Whitney-Eckstein Co., Binghamton, N. Y. Gold Medal Timothy; guaranteed 99.75% pure; found to be 93.27% pure and to contain 6.5% redtop slightly ergoted.

Whitney-Eckstein Co., Binghampton, N. Y. Timothy Red Top and Clover Mixture; guaranteed 99.5% pure; found to be 96.9% pure and to contain 3.8% inert matter.

A few samples showed ergot.

The viability of the seed as a whole compared favorably with that observed in previous years.

CONCERNING DEFICIENCIES

(1) Local seed merchants are notoriously careless in the matter of preserving guaranty tags. The law is mandatory but thoroughly ineffective in respect to guaranty displayal (see bulletin 205, pp. 12-13). The lack of guaranty statement in connection with the record against which the notation (1) occurs should not be construed as indicating a belief that the wholesaler did not furnish a guaranty as required by law, for as a matter of fact it has been developed in previous

inspections that the concerns thus indicated have been very scrupulous in this respect. It means simply that the sampling agents noted no such guaranties attached to the packages from which samples were drawn. The actual contents of pure seed found in each case is indicated in *italics*, since no guaranty statement can be furnished.

(2) Guaranty not maintained; guaranty 98, purity 96.45; contained a considerable proportion (4.4%) of oats.

(3) Guaranty not maintained; guaranty 99, purity 97.68; contained a considerable proportion (1.7%) of oats.

(4) Guaranty not maintained; guaranty 99.75, purity 93; contained a large amount (6.2%) of timothy and redtop.

(5) Guaranty not maintained; guaranty 98, purity 97.5; concontained 2.5% of inert matter.

(6) Contained approximately 4,000 millet seed per pound infected with smut. These are included among the 4,320 weed seeds being considered "weed seeds" as defined in the law.

(7) Guaranty maintained; guaranty 96, purity 95.5; contained 2.4% foreign seed and 2.1% of inert matter.

(8) Guaranty not maintained; guaranty 99.5, purity 98.13; contained a considerable proportion (1.8%) of barley.

(9) No guaranty statement; low purity (92.84%); contained large amounts (7.2%) of barley.

(10) Guaranty not maintained; guaranty 99%, purity 98.19%; contained 1.7% foreign seed, mostly barley.

(11) Contained 450 ergot per pound.

(12) Guaranty not maintained; guaranty 99.5%, purity 99%.

(13) Guaranty not maintained; guaranty 99.7%; purity 99.3%.

(14) Guaranty not maintained; guaranty 99.1%; purity 98.4%; contained considerable alsike and red top (1.2% foreign seed).

(15) Guaranty not maintained; guaranty 97.65%; purity 92.5%; contained 7% foreign seed, including much alsike and red clover.

(16) Guaranty not maintained; guaranty 98%; purity 97%; contained 1.5% foreign seed, including alsike and red top and 1.5% inert matter.

(17) Guaranty not maintained; guaranty 99.75%; purity 93.27%; contained 6.5% redtop slightly ergoted.

(18) Field peas, soy bean and sweet clover do not need to be guaranteed as to purity under provisions of state law.

(19) Guaranty not maintained; guaranty 99.5%, purity 96.9%; contained 3.8% inert matter. Mixture was approximately ⅗ redtop. ⅓ clover and 1/25 each of timothy and inert matter.

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

BLACKBERRIES OF NEW ENGLAND—THEIR CLASSIFICATION

By EZRA BRAINERD and A. K. PEITERSEN

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BULLETIN 217: BLACKBERRIES OF NEW ENGLAND—THEIR CLASSIFICATION

By Ezra Brainerd and A. K. Peitersen

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I. PRESENT SYSTEMATIC STATUS OF RUBUS

Rubus is one of the most polymorphic genera in the entire plant kingdom. Like Rosa, Hieracium, Crataegus, Salix, and a few other genera it includes many minutely different forms and varieties which are intermediate between the more or less distinct species. This is especially true when one considers the Eubatus or blackberry group. For this reason our native blackberries have been a puzzle to the ordinary herbarium systematist, and at the same time they have afforded a perfect paradise to the species-maker.

The difficulty of applying the ordinary methods of botanical classification to this group is most clearly seen in the confused and highly inconsistent treatments it has received in the various American as well as European manuals and monographs. The latest edition of Britton's (1)* manual recognizes only 10 species of blackberries growing in northeastern United States and Canada, while Gray's (2) manual which covers somewhat less territory recognizes 30 species besides several varieties and forms. The names of only six of these so-called species appear in both of these standard manuals. Rydberg (3) in his monograph of the North American blackberries recognizes 24 species and 72 hybrids for this same territory. Blanchard, who has for a number of years made a most thorough and extended study of our New England blackberries, published (in 1904-1907) detailed descriptions of 35 species and five varieties of blackberries found in New England. None of these 40 names appear in Britton's second edition of the Illustrated Flora (1913); not even as a synonym. Bailey (4) in his recent treatment of Rubus puts all our New England blackberries into a species-group and coordinates it, by serial numbers, with such European species as *Rubus laciniatus* Willd. and others of equal rank. Our dewberries receive the same harsh treatment, with the exception of *Rubus hispidus* L. which is given specific rank and serial number.

The disagreement among European students of Rubus as to what constitute a species in this genus is equally pronounced. Sudre (5) in his recent monograph of European Rubi illustrates and describes 110 species for all Europe. Rogers (6) lists 100 species of the same genus for England alone.

II. THE OBJECT OF THIS STUDY

The causes of these highly discordant opinions among the students

*Figures in parenthesis refer to citations at the close of this bulletin.

of Rubus concerning the status of its species seem to us to be chiefly the following:

(*a*) Too great a reliance upon herbarium specimens and a failure to study sufficiently the life history of the growing plants in field and in garden cultures.

(*b*) Failure to appreciate the variations in the supposed specific characters of these plants due entirely to the environmental conditions under which the plants grow.

(*c*) Lack of appreciation of the extent of inter-breeding of the blackberries in the wild and imperfect knowledge of the laws of inheritance, in accordance with which opposed parental characters are transmitted to their hybrid offspring.

In undertaking a critical examination of this sub-genus our aim, therefore, has been to determine as far as possible the origin of these numerous polymorphic forms and their true relationship to one another. In our endeavor to solve this problem we have not only carefully examined all available herbaria material but we have made extensive as well as intensive studies of the plants both in the field and in the experimental garden. We have focused our attention mainly upon New England forms and more especially those found growing in Vermont. The advantages of limiting the field of research to such a restricted area are obvious, while, on the other hand, it is fairly safe to assume that what is true of New England or Vermont blackberries is probably true of blackberries found in other localities.

The present treatise is based upon the results of this study and presents what seems to us to be not only a comparatively simple systematic arrangement of New England blackberries but at the same time expresses very nearly the true relationship of these various forms as they occur in the wild.

III. Methods Used in Determining the Systematic Rank of a Given Plant

Treatises on the blackberry flora of local or restricted areas prepared by authors who were not sufficiently familiar with the plants in this group in other localities have caused much needless confusion. A large part of the duplication and misapplication of names so common in this species has come about in this fashion as has been pointed out by Sudre (5) and others. In order to forestall such criticism in connection with this article it may be mentioned that the authors have made special efforts to acquaint themselves with the forms of Rubus

outside of New England, both native and foreign. Most of the large herbaria in this country have been visited and the plants most carefully studied. . The senior author has spent a considerable part of his time for the past 25 years in a critical study of this genus (12, 13). During this time he has travelled and collected plants in nearly every State in the Union. His own herbarium of Rubus is probably as complete as any to be found in this country. For the past seven years the junior author has been associated in this work and has in a similar manner covered most of the Northern and Eastern States. It must also be noted that about 90 percent of the blackberries found in the United States are represented in the New England flora.

On the other hand, our investigations have convinced us that a far greater error has been committed by certain workers, especially in this country, who have relied almost entirely upon a general comparison of dried specimens of plants of this polymorphic group as a basis upon which to determine their systematic rank. There seems to be conclusive proof that some of our ablest systematists are not capable of recognizing the blackberries which they themselves have named and described. This fact alone shows the extreme need of an intensive study of this genus-group. We have, therefore, been compelled to supplement our general observations of this group with a more minute examination of the plants dealt with in order to form a more substantial background for their classification. Such a work, it was hoped, might also add materially to our knowledge of the methods by which new forms (species if you like) originate in the wild. It must also be fundamental to any work which aims at the improvement of horticultural varieties for the reason that nearly all the cultivated forms are native wild plants which have been improved by hybridization or selection, or by both.

The plants listed in the following pages have been critically studied:

1. As to their distribution and development in the wild.
2. As to their behavior in garden cultures and controlled plots.
3. As to the characters of the progeny of supposed natural hybrids.
4. As to the behavior of the progeny of wild forms when artificially crossed.

1. Several stations, especially rich in blackberry forms, scattered over Vermont have been visited at least twice annually for a number of years, the first visit being made when the plants were in flower, the second later in the season when they were in fruit. Herbarium specimens have been collected at these stations for future study and com-

parison, and the distribution of the different forms have been carefully noted. In the case of a natural hybrid the proximity of the two parent species has always been ascertained. The time of flowering of the parent plants, their sterility as shown by their spore and ovule condition, and other factors which determine the probability of such plants hybridizing in the wild have received careful consideration.

Most of the type stations for the new forms of New England blackberries have been visited, the reported species or form generally found growing in that vicinity located and observation made regarding the associated forms. These have served us as a check to the original type specimens of the author who first collected and described them.

Seasonal differences in form and variations due to environmental factors such as shade and sunlight, humidity, altitude, water contents of the soil, etc., have been carefully noted and interpreted as far as such general observations of plants grown under such uncontrolled conditions would safely permit.

2. Specimens of nearly all forms of blackberries that have been reported from Vermont and a few from outside the State have been collected and transplanted to the experimental garden. By a comparison during the entire growing seasons for seven years of about 60 different forms growing side by side and under almost identical environmental conditions, it has been possible to correct many nomenclatorial errors which have found their way into the systematic literature of Rubus. One case may be cited as an illustration. *R. frondosus* Bigelow and *R. recurvans* Blanchard have been considered by most American authors as two distinct species. The most important character used in distinguishing between these two supposed species is the leafy-bracted inflorescence of *R. frondosus* and the more or less lack of such leafy bracts in *R. recurvans*. Our garden cultures have shown that where these two plants are grown side by side there is very little difference in the amount of the leafy bracts. It has also been shown that the leafy bracts are present in both plants if grown in the shade while a more or less lack of such leafy bracts results if grown in the sunlight. This character, therefore, cannot be relied upon as a specific character and we must consider *R. recurvans* as a mere form of *R. frondosus* in view of the fact that the latter name antedates the former.

The effects of environmental factors upon the vegetative characters of a few wild forms have been tested by growing several shoots from the same plant in plots under greenhouse conditions, where such factors as soil temperature, air temperature, humidity and light could

be definitely controlled and measured. Continuous records of these factors in the different plots were kept for several months and the corresponding plants compared. Plate II shows two corresponding similar shoots of plant No. 7-2 *R. allegheniensis* × *frondosus* grown under different conditions. The difference in the size and number of prickles and in the number of glandular hairs on the two shoots is marked. How easy might it not be for the herbarium systematist to make two species of this one plant!

3. Seedlings of about 50 wild forms, mostly suspected hybrids, have been grown and in several cases indisputable evidence of the hybrid origin of the parent plant have been obtained by the more or less complete reversion of the seedlings to the parent species. The most striking examples of such reversions are shown in such forms as *R. trifrons* Blanchard, *R. groutianus* Blanchard, *R. allegheniensis* × *frondosus* and *R. allegheniensis* × *canadensis*. Plate III, figs. 1 and 2 show two seedlings of plant No. 122-1 *R. allegheniensis* × *frondosus*, selected to illustrate segregation in the shape of the leaf.

4. More than 30 different crosses have been effected artificially between the different wild forms, and the resulting plants are at present under observation in the plant breeding gardens of the station. In general the characters of these seedlings are intermediate between those of the two parents, although some of these hybrid plants show a greater resemblance to the mother than to the father plant. Some of these first generation plants are almost exact duplicates of the corresponding hybrids found in the wild.

IV. HYBRIDITY AMONG AMERICAN RUBI

No matter which of the several proposed theories we accept as a satisfactory explanation of the evolutionary differentiation of the organic world in general, we must admit that as far as the Rose family is concerned, and more especially the genus Rubus, numerous new forms are at present being produced in the wild through hybridization. Evidences of the hybrid origin of many American blackberries are so frequent and so convincing that no thorough student of Rubus will question its occurrence. It seems to us that it is no longer a question of whether or not new species of blackberries are produced in the wild through natural hybridization but rather that it is a question whether hybridization is not the primary or only factor in the production of new species within this group. If new forms are developed by natural hybridization within the genus Rubus—an inference which the evi-

dence at hand supports—it may be that it is also a very important factor in the evolution of plants within other groups, as has already been suggested by Lotsy (7) and others.

Although a more detailed discussion of the subject of spontaneous hybridization will be soon published it may not be amiss to enumerate briefly some of the more important facts which have led to the conclusion that inter-crossing between the different species of blackberries in the wild is of common occurrence.

1. All New England forms of blackberries show a more or less degree of infertility. In all our search for new forms we have yet to find a blackberry that is 100 per cent fertile. On the other hand, we have had under observation for the past seven years several colonies in the field as well as numerous individual plants in the gardens of the plant breeding station which during this time have matured only a few scattered drupelets or none at all, although the seasons have been favorable for fruit production. This infertility is largely due to the impotency of the pollen; a character which Jeffrey (8, 9, 10) and others claim is present only in plants of hybrid origin. The pollen condition of the New England blackberries shows a very wide range of variation. For instance, in *R. allegheniensis* Porter the percentage of morphologically perfect pollen is about 96, while that of *R. hispidus* L. is less than 10 (plate IV). Between these two extremes exists all grades of intermediacy. This sterility or partial sterility of all plants within this group is at least suggestive of their hybrid origin.

2. Intermediate forms between all of the well recognized species exist in the wild. In the same field one may often find a colony of perfectly typical *R. hispidus* L. and a few rods distant another colony of equally typical *R. setosus* Bigelow, and also there may be half a dozen other colonies quite different from each other and yet all intermediate between these two fairly well marked species. This situation is to be found in nearly any other two closely related species of Rubus. The presence of these many intermediate forms can be logically accounted for if we assume that the two species interbreed.

3. It will be noted that wherever there is found an intermediate between any two forms of blackberries one can usually locate the two suspected parents in close proximity. At every station for *R. permixtus* Blanchard visited by us, we have not failed to find *R. hispidus* L. and *R. allegheniensis* Porter growing in the vicinity. This is equally true of any other intermediate form listed in the following pages as a hybrid. Such circumstantial evidence confirms our belief in their bastard origin.

4. Plants of the blackberry sub-genus are very variable. This characteristic of the group is familiar to all students of Rubus. Their vegetative structures are greatly modified by the conditions under which they grow (plate V). In fact, the perfect chaos now existing in the systematic literature is largely due to the misinterpretation of these purely vegetative variations. Since students of evolution are almost unanimous in their assertions that hybridization increases variation in vegetative characters, it may be inferred that the reverse also is true; that vegetative variation is an index of hybridization.

5. Seeds from the selfed flowers of a number of suspected hybrids have been grown and these plants in the majority of cases show a reversion to the supposed parent types (plate III), which of itself, to our mind, is a positive proof of hybrid origin.

6. A number of artificial crosses have been effected between different species, a detailed account of which will be published soon. The plants from these crosses are almost identical with the suspected wild hybrids. It therefore seems reasonable to assume that the wild forms have had a similar origin.

7. In more than 30 different combinations of New England blackberries that were cross pollinated, not one failed to produce viable seeds. This would indicate that they are all capable of cross-fertilization if given a chance.

The only logical conclusion that can be drawn from such evidence is that at least New England blackberries hybridize in the wild and that this occurs quite frequently.

In considering the hybrids of Rubus we must not overlook the fact that nearly all specific characters in this genus are quantitative and not qualitative characters. One species of blackberry may differ from another species in the width of its leaflets, in the amount of pubescence, in the erectness of cane, in the length of inflorescence, etc. It is nearly always a question of a more-or-lessness of the particular characters which distinguish it from the other plants of this group. A hybrid, therefore, will nearly always show an intermediacy in the characters which are present in varying degrees in both of the parents, and besides, these compromise characters will also possess the characters in diminished form which are present in only one of the parents. The offspring of such a hybrid as a rule will not show a segregation into pure dominants and recessives in the ordinary Mendelian ratio. On the other hand there will be found all grades of intermediates. This is characteristic of a blend inheritance. Whether or not these intermediate forms can be accounted for by the Nilsson-Ehle hypo-

thesis we do not know. Even in some cases, as in *R. permixtus* Blanchard, *R. frondisentis* Blanchard and *R. abbrevians* Blanchard, these hybrids appear to be more or less fixed.

V. Hybridity as It Affects Classification

The student of evolution, who wishes to express the true relationship of the various forms which he finds in such a polymorphic genus as Rubus, is very much embarrassed in coordinating his facts with any acceptable scheme of classification. In order to avoid adding new specific names to the already long and cumbersome lists such terms have been employed as sub-species, varieties, forms, etc. These, however, in many cases do not express the genetic relationship of the plants thus designated.

Sudre (5) in his monograph of European Rubi uses the term "species-group" to designate a number of closely allied forms consisting generally of one primary or dominant species and a large number of subordinate forms which he terms "species of the second order," "species of the third order," "varieties," "forms," etc. Such use of a binomial to designate a collective species is very unfortunate, although it has obvious advantages from the systematic point of view. A hybrid between two collective species would have no place in such a scheme but would in most cases be placed in an entirely different species-group. For instance, *R. permixtus* Blanchard by such a treatment would be grouped with *R. setosus* Bigelow where it does not belong. It is very probable that many of Sudre's subordinate forms are hybrids.

It must be admitted that the number of forms included in a species will depend largely upon the author's conception of a species as well as upon the importance he assigns to a certain character. Nevertheless there are some forms that stand out prominently from all the closely allied forms, differing from them in one or more well-marked characters. These, if they breed "true to type," should be considered valid species even if they are remote crypto-hybrids. Other forms that unquestionably are of recent hybrid origin should be designated as such by a combination of the specific names of their parents or suspected parents.

VI. The New England Blackberries

New England blackberries do not differ very much from blackberries grown in other parts of the world. They have perennial roots and biennial, woody stems; the stems develop the first year and die the

second year after flowering and fruiting. The stems range from weak trailers to erect canes from two to three meters high. Their leaves are palmately compound, having as a rule five more or less stalked leaflets, but in some of the dewberry types those of the second year's cane as well as of the first year's cane are trifoliolate or even unifoliolate. Their flowers are borne on more or less contracted cymose-racemes, the terminal flower opening first. The fruit consists of partly cohering drupelets which at maturity break off with the fleshy receptacle. The canes, leaves and inflorescence are variously covered with simple hairs, gland-tipped hairs and prickles.

In considering the specific characters of the blackberries it must be kept in mind that their canes are of two kinds: the first year's cane or turion and the second year's cane which bears the flowers and fruit. Any complete herbarium specimen, therefore, should include a turion mounted so as to show both surfaces of the leaflets, a portion of the old cane showing the inflorescence and a similar portion collected later in the season showing the mature fruit. With any of the above mentioned parts lacking it is not easy to identify a specimen with any degree of certainty. The turions vary from stout, erect, somewhat drooping canes to weak, prostrate runners; these in late fall show a more or less tendency to root at the tip and propagate the plant vegetatively in this way. The canes are terete as in the dewberry types or they may be more or less grooved or furrowed, the amount varying somewhat with the age of the cane. The alternate leaves in the high-bush forms are palmately compound and are generally 5-foliolate; in the dewberry forms 3-foliolate. The leaflets are either perfectly glabrous or are covered more or less with simple hairs and in some of the pubescent forms with gland-tipped hairs along the veins. The amount of pubescence varies somewhat with the season's growth. The stems, petioles, petiolules and larger veins are covered in divers ways with prickles and gland-tipped hairs, these varying greatly in size and shape in the different species, or they may be almost devoid of prickles and hairs of any kind, as in *Rubus canadensis* L.

The fruiting canes while living retain to a large extent their turion characters. But the second year's growth, which is always axillary, may differ widely from the first year's growth in the shape and size of the leaflets, amount of pubescence and in other respects. The branches may be long and leafy and terminated by the inflorescence or they may consist merely of a short cymose-raceme subtended by a few leaves. The leaves are mostly 3-foliolate. Their shape, surface covering, serrations, etc., vary as widely as do the same characters of the leaves on the

turions. The inflorescence varies from a few-flowered corymb-like arrangement of the flowers as in the dewberry types to an elongated raceme-like arrangement as in most of the high-bush forms. Although this type of inflorescence for the sake of brevity may be referred to in the following pages as either a raceme or a corymb, it must be understood that in all blackberries and dewberries alike the inflorescence is a false raceme, in spite of numerous statements in current literature to the contrary (see Card's Bush-Fruits; also Bailey's Evolution of Our Native Fruits) (14). The terminal bud opens first while the remaining buds open in the order of a true raceme. The flowers in all New England forms are white or cream colored. The rachis and pedicels may be either smooth and glabrous or variously covered with prickles, gland-tipped hairs and simple hairs. The fruit consists of few to many partly coherent drupelets which break off with the fleshy receptacle when mature. Its color varies from jet black to purple and red, amber-colored albino forms occurring in some species.

As has been pointed out, the blackberries are conspicuous for the characters which they have in common rather than for those which enable us to distinguish one form from another. The characters used in differentiating between the different species are nearly always relative characters. The dewberries tip profusely late in the season; but it must be noted that all New England forms of blackberries tip if their turions touch the ground. The inflorescence of the dewberries resembles that of a cymose-corymb while in most of the high-bush forms the flower cluster resembles more nearly a raceme; but the general plan of all is that of a false raceme. Moreover, all New England forms have simple hairs, gland-tipped hairs and prickles in varying amounts; even the smooth, glabrous, eglandular, unarmed form of *Rubus canadensis* L. possesses these structures in rudimentary form. If these protodermal outgrowths are not noticeable in the mature plants they are at least present in the very young seedlings. In fact, it is very difficult to select a single character possessed by one form or species of blackberry which is not common to all New England forms in varying degree.

The blackberries of New England are distributed from the highest mountain peaks to the lowest valleys. They are adapted to growing in the open. *Rubus canadensis* L. is practically the only species that is found growing in dense forests. They are especially prolific in alluvial soils which have been cleared of their forest trees. Here in open pastures, along stone walls and in abandoned fields they have found a congenial soil in which to grow and multiply.

There are three fairly well marked groups of New England blackberries; each group including four valid species. *R. allegheniensis* Porter, *R. argutus* Link, *R. pergratus* Blanchard and *R. frondosus* Bigelow comprise the first or high-bush group. These species have erect canes and pubescent leaves. In striking contrast to these high-bush forms is the dewberry group which includes *R. hispidus* L., *R. flagellaris* Willd., *R. enslenii* Tratt. and *R. baileyanus* Britton. These species have trailing stems, trifoliolate leaves and corymbose-like inflorescence. Somewhat intermediate between these two groups and yet quite distinct from either of them are the semi-erect species which include *R. setosus* Bigelow, *R. vermontanus* Blanchard, *R. elegantulus* Blanchard and *R. canadensis* L. These have glabrous leaves and canes. All other forms of blackberries found in New England can be accounted for by the inter-crossing of these twelve species. Plate VI shows in a diagramatic way the parentage or suspected parentage in some cases, of these various New England forms.

In the descriptions and keys which follow our aim has been to give only the marked or differentiating characters for that particular species or hybrid.

KEY TO THE TWELVE SPECIES OF NEW ENGLAND RUBUS § EUBATUS

a. Stems erect, or ascending and recurving; leaves on new canes mostly 5-foliolate* *b.*

b. Leaves of early summer densely short-villous or velvety on the lower surface *c.*

c. Short gland-tipped hairs abundant; seeds 2 mm. long; racemes about 14-18-flowered ..... **R. allegheniensis,** 23.

c. Gland-tipped hairs and bristles absent; seeds 2½ mm. long†; racemes 8-12-flowered *d.*

d. Terminal leaflet on new canes oval or oblong-ovate *e.*

e. Prickles on stem 5-7 mm. long with broad base; at least lower pedicels armed with small hooked prickles, **R. argutus,** 27.

e. Prickles on stem 2-4 mm. long, about 6 to the dm.; pedicels unarmed ..... **R. pergraus,** 29.

d. Terminal leaflet on new canes suborbicular or broadly ovate.

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*At high altitudes occurs a form of *R. setosus* with leaves mostly 3-foliolate and stems often reclining.

†In bulk, or weight, twice as large as in *R. allegheniensis*, i. e. $(2)^3 : (2\frac{1}{2})^3$.

Bracts of raceme nearly all leafy; leaflets short, acuminate,
R. frondosus, 31.

b. Lower surface of leaves glabrous *g.*

g. Gland-tipped hairs and bristles absent *h.*

h. Prickles absent from stem, or rudimentary,
R. canadensis, 35.

h. Prickles of the stem needle-like with broad, flattened base, about 4 or 5 to the cm....**R. elegantulus,** 37.

h. Prickles of the stem setaceous, about 20 to the cm.,
R. vermontanus, 39.

g. Gland-tipped bristles abundant on stem, petiole, raceme and calyx; stem beset also with stronger glandless bristles curving downward, about 40 to the cm.,
R. setosus, 41.

a. Stems trailing; leaves on new cane mostly 3-foliolate *j.*

j. Stems and petioles armed with many slender reflexed bristles,
R. hispidus, 43.

j. Stems and petioles armed with stiff prickes 1-3 mm. long, 1-5 to the cm.; pedicles few, erect, elongate *k.*

k. Leaves somewhat sharply serrate, slightly hairy beneath, especially the veins; prickles curved; pedicels usually 2-5,
R. flagellaris, 45.

k. Leaves with coarse broadly rounded mucronate teeth, pubescent beneath; pedicels 1-3; these and the stems often with stalked or sessile glands .....**R. baileyanus,** 49.

k. Leaves glabrous beneath, ciciolate; prickles minute and few; pedicels often only one, eglandular.....**R. enslenii,** 47.

KEY TO SOME NEW ENGLAND HYBRIDS AND BLEND SPECIES OF RUBUS § EUBATUS

a. Stems erect, or ascending and recurving *b.*

b. Leaves of early summer velvety or somewhat pubescent on lower surface *c.*

c. Stems and inflorescence bearing gland-tipped hairs or bristles *d.*

d. Terminal leaflets on new cane oval or oblong-ovate *e.*

e. Pedicels armed with pungent hooked prickles,
R. alleghenienſis X argutus, 53
(R. andrewsianus).

e. Pedicels without hooked prickles *f.*

f. Petioles on new cane beset with gland-tipped hairs *g.*

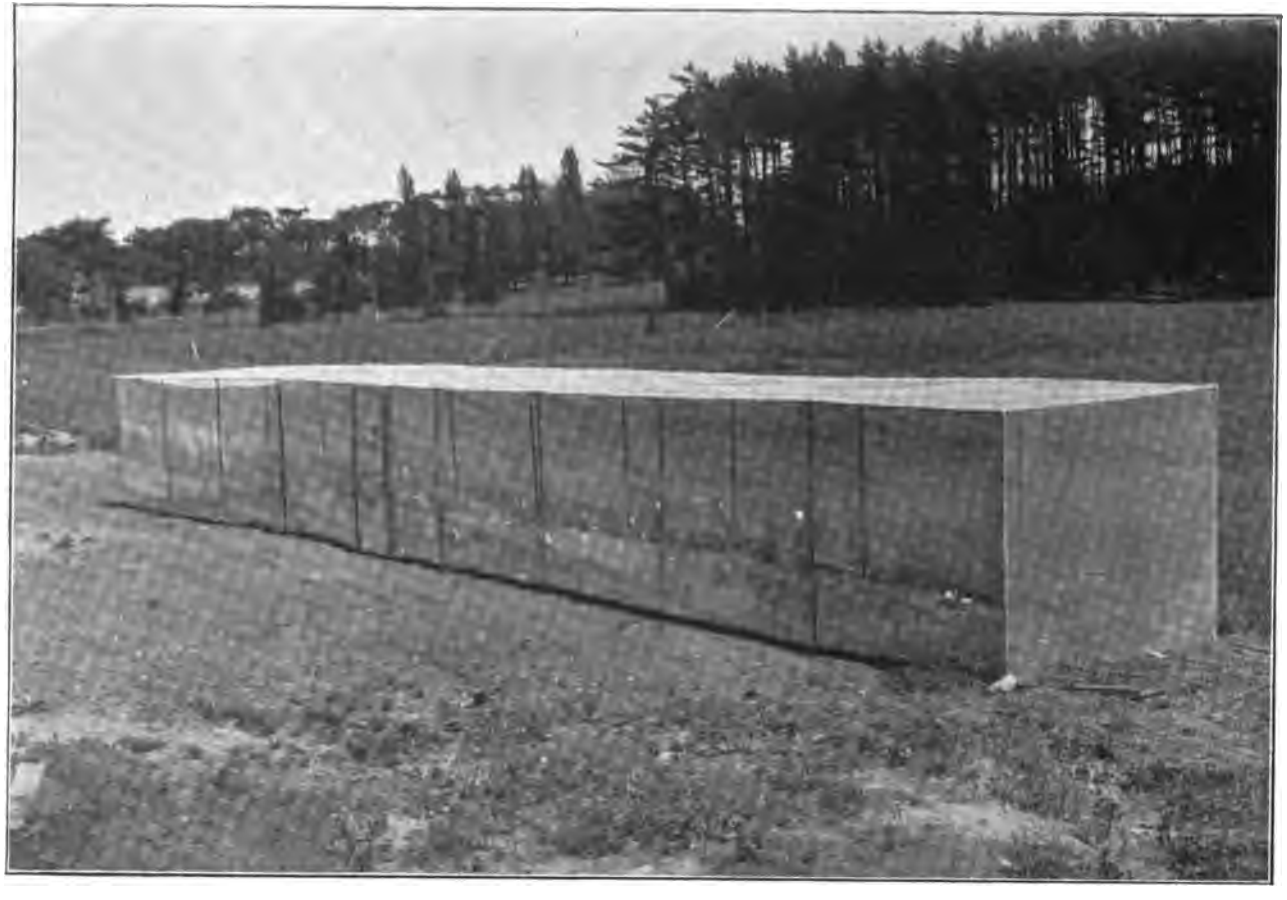


PLATE I

Cage in which the twelve species of New England blackberries were grown.

PLATE II

Rubus alleghenlensis X frondosus

Two shoots from the same plant grown under different external conditions. The cane shown on the left (glandular one) is the third node of a shoot which grew in a plot having a high temperature, a low humidity and full sunlight. The cane shown on the right (glandular one) is the third node of a shoot which grew in a plot having a comparatively low temperature, a high humidity and the plants were shaded by three layers of cheesecloth.

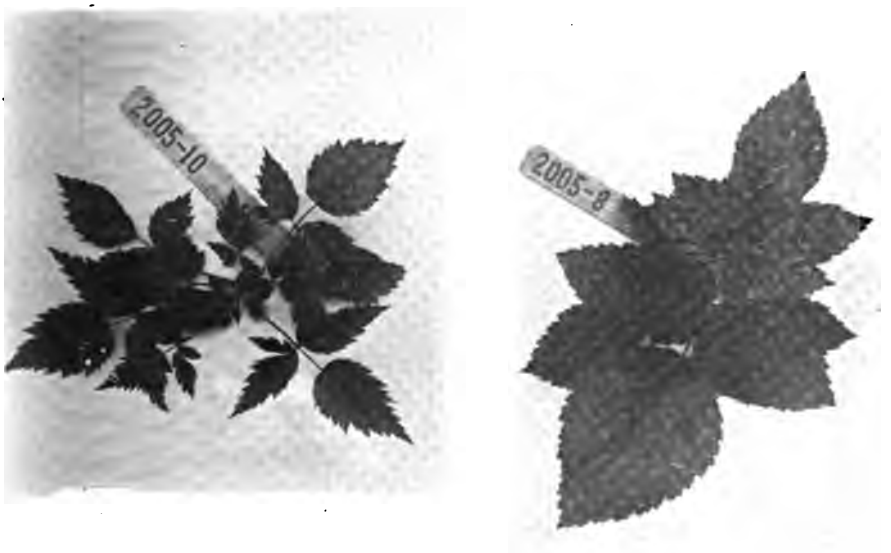


PLATE III

Rubus allegheniensis X frondosus

Two seedlings frcm selfed flowers of Plant No. 122-1 showing reversions to the parent types. Plant No. 2005-8 shows a reversion towards *R. frondosus* Bigelow in the orbicular shape of its terminal leaflet. Plant No. 2005-10 shows a reversion toward *R. allegheniensis* Porter in having a narrow, ovate terminal leaflet.

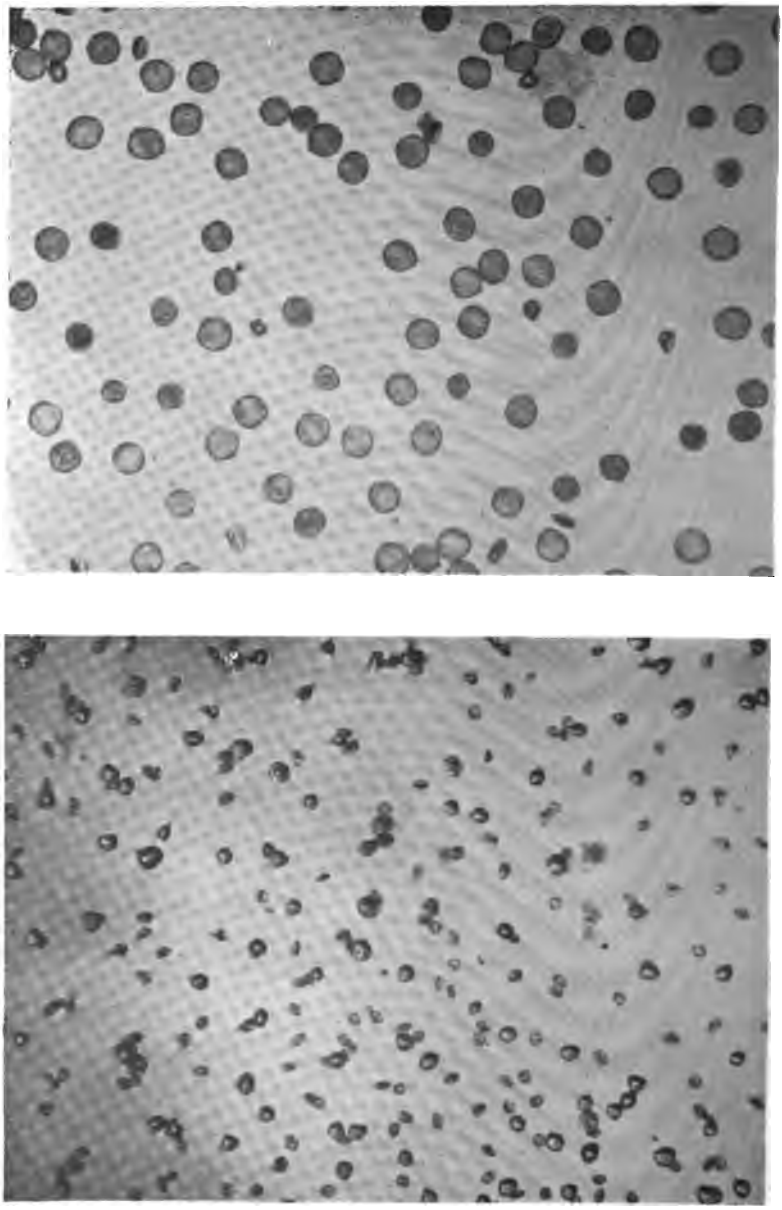


PLATE IV

Figure 1. A microphotograph of the pollen grains of *R. alleghenienses* Porter, X 100. About 96% morphologically perfect grains and considered "good pollen."

Figure 2. A microphotograph of the pollen grains of *R. hispidus* L. X 100. Less than 10% morphologically perfect grains and considered "poor pollen."

g. Cane and inflorescence sparsely beset with gland-tipped hairs and prickles.....
R. allegheniensis X canadensis (R. orarius).

g. Cane and inflorescence copiously beset with gland-tipped hairs and prickles *h.*

h. Racemes 8-11-flowered, short cylindrical; seeds 2½ mm. long .....**R. pergratus X setosus,** 63 **(R. frondisentis).**

h. Racemes 14-18-flowered, elongate; seeds 2 mm. long .....**R. allegheniensis X setosus,** 61 **(R. glandicaulis).**

f. Petioles on new cane glandless, copiously armed with hooked prickles *i.*

i. Prickles on new canes with broad, flattened base; petals about 1½ cm. long; racemes elongate, **R. allegheniensis X elegantulus,** 57 **(R. flavinanus).**

i. Prickles on new cane setaceous; petals about 1 cm. long; racemes cylindrical, **R. allegheniensis X vermontanus,** 59 **(R. fraternus).**

d. Terminal leaflets on new cane broadly ovate *j.*

j. Prickles on stems setaceous, **R. frondosus X setosus,** 65 **(R. abbrevians).**

j. Prickles on stems stout, 3-5 mm. long, **R. allegheniensis X frondosus.**

c. Stems and inflorescence without gland-tipped hairs or bristles *k.*

k. Terminal leaflet on new cane broadly ovate; pedicels armed, **R. argutus X frondosus,** 55 **(R. jeckylanus).**

k. Terminal leaflet on new cane oval or ovate; pedicels unarmed .....**R. canadensis X pergratus.**

b. Leaves glabrous on the lower surface *l.*

l. New cane bearing gland-tipped hairs *m.*

m. Pedicels mostly 1-2 cm. long; cane slender, **R. setosus X vermontanus (R. vermontanus** var. **viridifolius).**

m. Pedicels mostly 2-5 cm. long; cane stout, **R. canadensis X setosus,** 67 **(R. junceus).**

l. New cane without gland-tipped hairs *n*.

n. Prickles of the stem remote, 1 or 2 to the cm.,
R. canadensis X vermontanus.

n. Prickles of the stem numerous, about 20 to the cm.,
R. elegantulus X vermontanus.

n. Prickles of the stem very numerous, about 50 to the cm.,
R. elegantulus X setosus (R. groutianus).

a. Stems prostrate (new shoots sometimes ascending but soon reclining and trailing) *o*.

o. Stems and inflorescence bearing gland-tipped bristles *p*.

p. Leaves of early summer velvety on the lower surface *q*.

q. Terminal leaflet orbicular; racemes 1-10-flowered, lower flowers leafy-bracted .....**R. baileyanus X frondosus,** 75 **(R. arenicola).**

q. Terminal leaflet elongate; racemes many-flowered, lower flowers not leafy-bracted *r*.

r. Prickles hooked; glandular hairs of uniform length,
R. allegheniensis X flagellaris, 71 **(R. elongatus).**

r. Prickles straight; glandular hairs of unequal length,
R. allegheniensis X hispidus, 69 **(R. permixtus).**

p. Leaves glabrous *s*.

s. Stems without prickles, beset with numerous recurved bristles .....**R. hispidus X setosus,** 77 **(R. trifrons) (R. jacens).**

s. Stems with bristles and slender prickles,
R. hispidus X vermontanus (R. cubitans).

o. Gland-tipped hairs and bristles absent *t*.

t. Leaves on new cane mostly 3-foliolate,
R. baileyanus X flagellaris, 79.

t. Leaves on new cane mostly 5-foliolate *u*.

u. Prickles large, hooked; pedicels armed,
R. argutus X flagellaris, 73 **(R. multispinus).**

u. Prickles slender, straight, pedicels unarmed,
R. flagellaris X frondosus (R. plicatifolius).

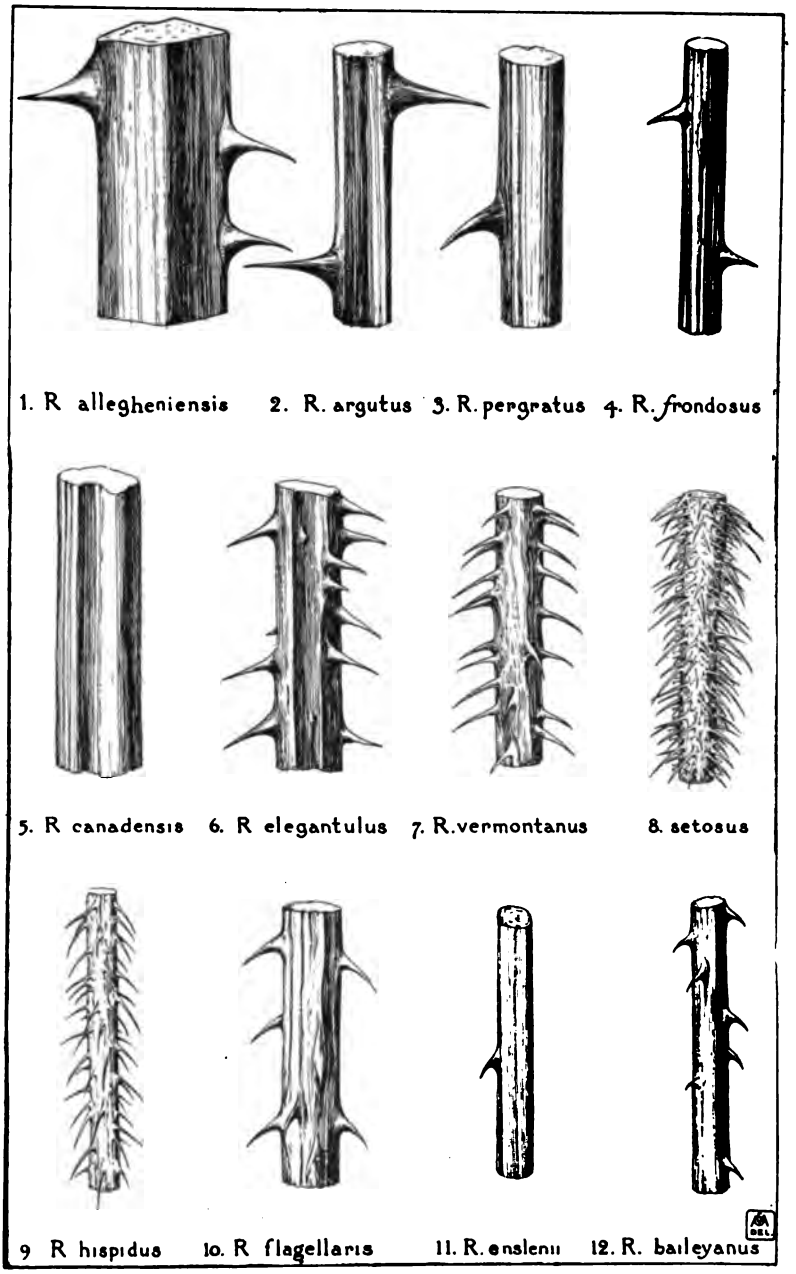


PLATE V

Drawings showing the stem character of the twelve species of New England blackberries. Redrawn from photograph. Natural size.

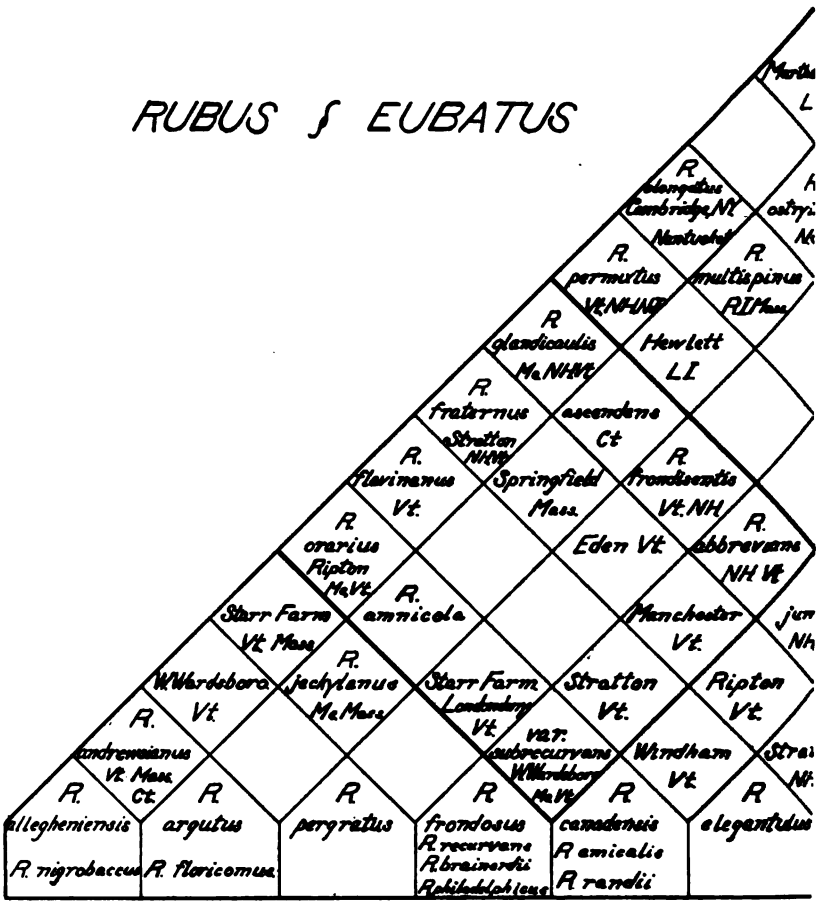
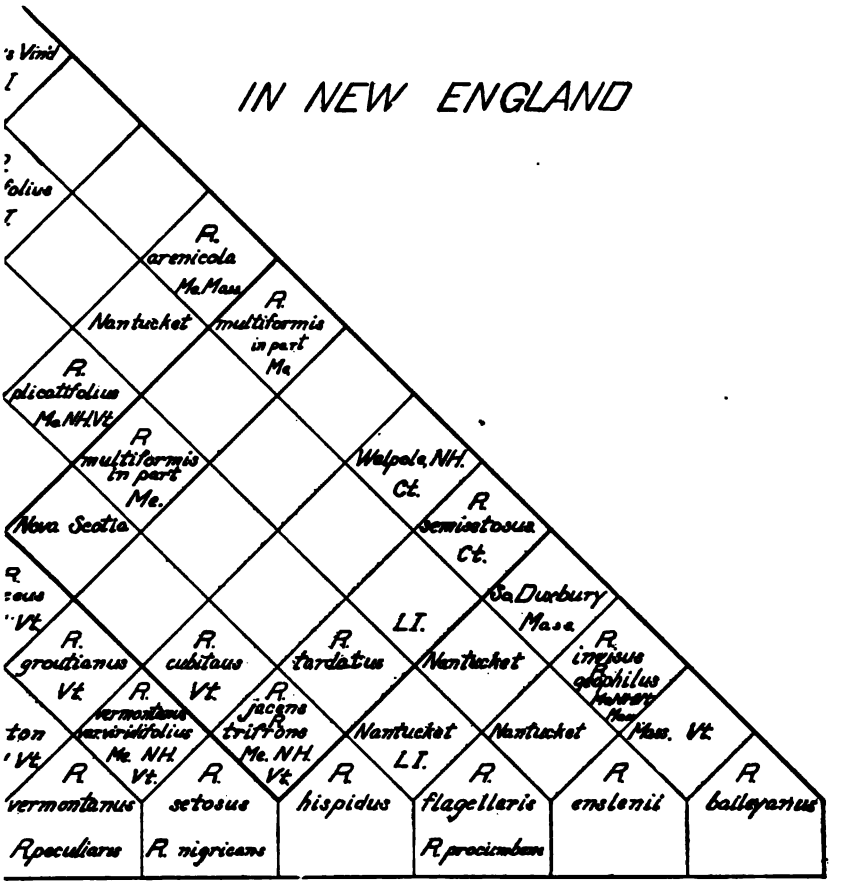


PLATE VI

A diagram showing the systematic arrangement of New England blackberries. The names appearing in bold type in the lower part of the diagram are the twelve valid New England species together with their synonyms which are shown in smaller type. In the squares above are indicated the hybrids



or suspected hybrids which have been found in New England and in most cases the States in which they were found are also indicated.

The synonym of such hybrids, whenever there are such, are also indicated in the same square. Thus *Rubus allegheniensis X elegantulus* occurs in Vermont and has been described as *Rubus flavinanus* Blanchard.

PLATE VII

R. allegheniensis Porter

Two-thirds natural size. Raceme of plant from Chipman Hill, Middlebury, Vt.

HIGH-BUSH BLACKBERRY

Rubus alleghenienses Porter, Bull. Torrey Club 23: 153. 1896
Rubus villosus montanus Porter, Bull. Torrey Club 17: 15. 1890
Rubus montanus Porter, Bull. Torrey Club 21: 120. 1894. Not *R. montanus* Ortman. 1852
Rubus nigrobaccus Bailey, Evol. Nat. Fr. 379. 1896

Stems erect, sometimes reddish, armed with stout, straightish prickles; stems and pedicels glandular-pubescent; leaves on turions mostly 5-foliolate, of early summer densely villous above, velvety beneath; racemes about 14-18-flowered; drupelets small; berries thimble-like and possessed of a peculiar spicy flavor; seeds about 2 mm. long.

Pollen only about 5% imperfect. Seedlings show little or no segregation in culture.

Time of blooming: May 28 to July 4.

Time of fruiting: August 10 to September 20.

Type station: Pocono Summit, Pa.

Distribution: Dry thickets and recent clearings throughout New England.

This is one of the purest and most distinct species of our New England blackberries. In the wild it shows quite a range of variation in color of stem, ranging from reddish to a pale green, and in the number and size of prickles and glandular hairs but these variations are largely due to environmental conditions under which it grows. An albino form also occurs. This plant was recognized by Porter who first described it as a mountain form of *R. villosus* Ait., but it must be borne in mind that what Porter then considered *R. villosus* was the "common high-bush blackberry" of Pennsylvania, *R. argutus* Link. So by way of contrast he called his plant a mountain form while in New England it constituted our common lowland blackberry.

Although this species is not represented by any of our cultivated varieties on account of its small and seedy fruit, its apparent hybrids with other wild species are very closely related to such horticultural varieties as: Ancient Britton, Badger, Dorchester, Eldorado, Lovett, Taylor, Agawam, Barnard, Erskine Park, Jumbo, Lawton, Snyder, Stone and Wachusett.

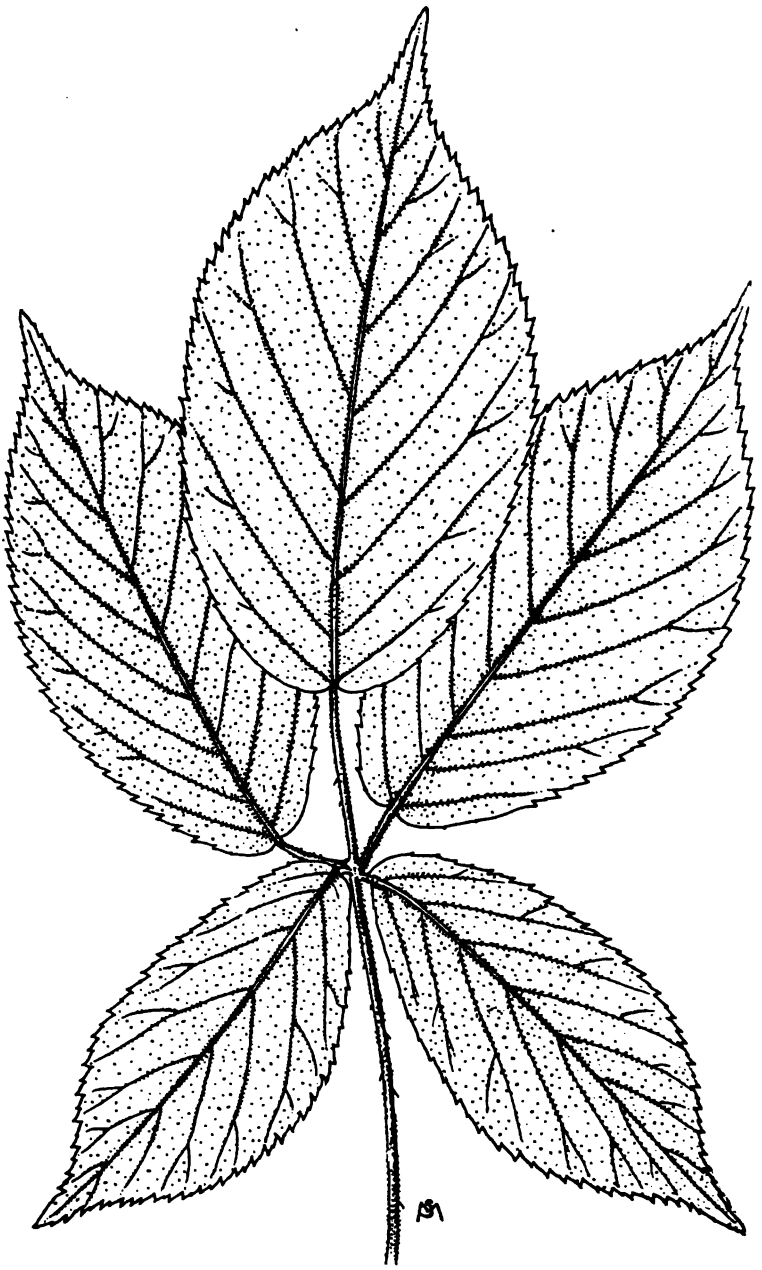


PLATE VIII

R. allegheniensis Porter

Four-fifths natural size. Leaf.

PLATE IX

R. alleghenicnsis Porter

Four-fifths natural size. Raceme and fruit from pubescent form.

PLATE X

R. argutus Link

Two-thirds natural size.

TALL BLACKBERRY

Rubus argutus Link, Enum, Hort. Berol. 2: 60. 1822
Rubus floricomus Blanchard, Am. Bot. 9: 106. 1905

Stems erect, deeply furrowed, glabrous, armed with prickles, 5-7 mm. long with a broad base; leaves on turions mostly 5-foliolate, in early summer densely short-villous beneath; petioles, petiolules and midveins somewhat pubescent and armed with stout usually hooked prickles; racemes 8-12-flowered; at least lower pedicels armed with small hooked prickles; drupelets about 30; seeds large, about 2½ mm. long.

Pollen about 20% imperfect.

Time of blooming: May 24 to July 1.

Time of fruiting: August 8 to September 21.

Type station: "North America."

Distribution: On dry grounds at low altitudes in southern New England.

Link's short but concise description and a careful examination of several leaves of the type specimen convinces us that Link's type is identical with the common high-bush blackberry of the central United States which is correctly figured and described in Britton's Ill. Fl., Vol. 11, p. 202, 1st ed., as *R. villosus* Ait., and as *R. argutus* Link in 2nd ed., p. 280, fig. 2301. It ranges from southern New England to North Carolina westward to the Mississippi. Appears constant throughout this territory but hybridizes freely with other species. An albino form also occurs.

Cultivated varieties whose probable progenitor is *R. argutus* are: Clyde, Dallas, Eric, New Rochelle, Tree Blackberry, Wallace and White Blackberry. Its crosses with *R. frondosus* Bigelow and *R. allegheniensis* Porter are also horticulturally important.

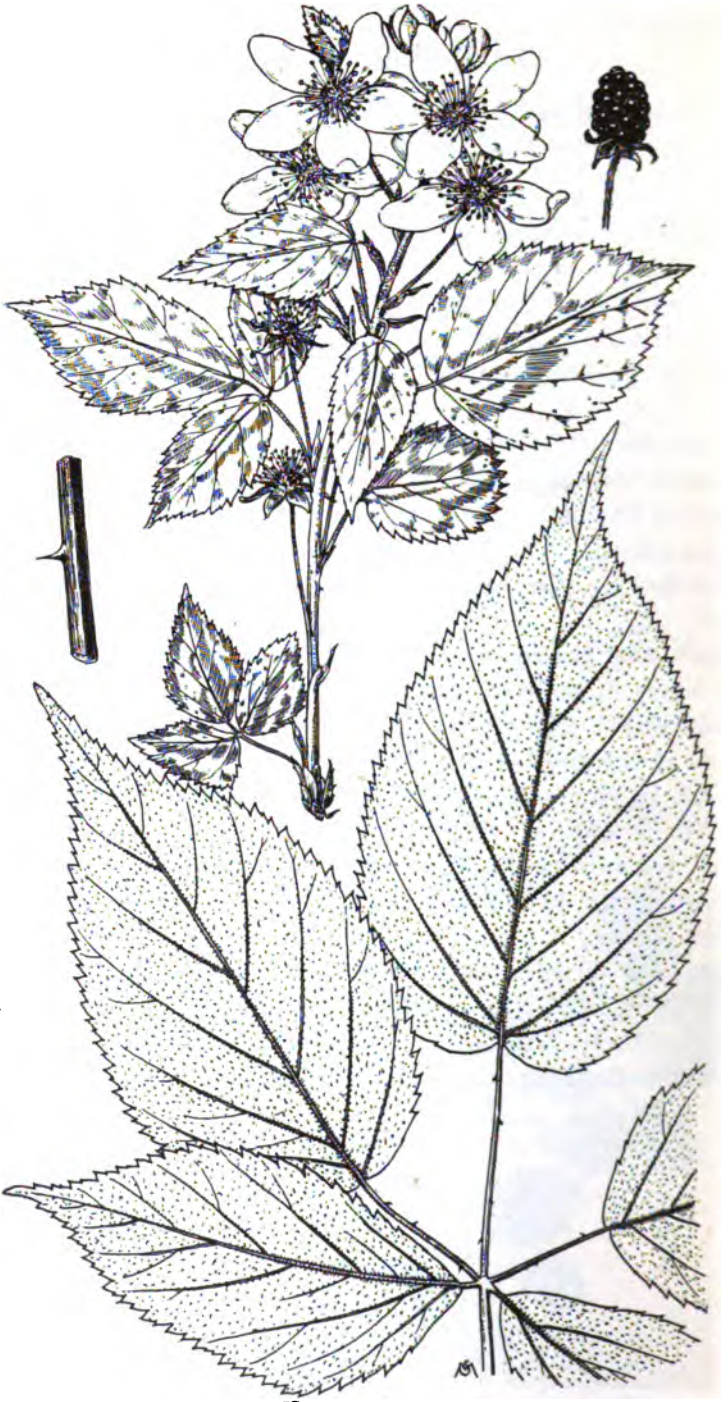


PLATE XI

R. pergratus Blanchard
Three-fifths natural size.

SHORT BLACKBERRY. SQUARE BLACKBERRY

Rubus pergratus Blanchard, Rhodora 8: 96. 1906

Stems ascending and recurving, furrowed, gland-tipped hairs and bristles absent; prickles 2-4 mm. long, broad-based and straightish, about 6 per dm. of cane; leaves on turions 5-foliolate, of early summer densely velvety beneath; terminal leaflet oval or oblong ovate; rhachis and pedicels densely villous, glandless; racemes short, 8-12-flowered; pedicels unarmed; fruit short cylindric and fleshy; seeds large, about 2½ mm. long.

Pollen about 70% imperfect. Seedlings do not segregate in culture.

Time of blooming: June 10 to July 18.

Time of fruiting: August 10 to September 12.

Type station: Alstead, New Hampshire.

Distribution: Thickets and woodland borders at medium altitudes throughout New England.

There are at present no cultivated varieties that are identical with this wild species, although its berries picked from the wild are often sold in the markets. By improvement, either by selection or by hybridization, it ought to produce a berry very desirable from the horticultural point of view.

PLATE XII

R. frondosus Bigelow

Four-fifths natural size.

LEAFY-FLOWERED BLACKBERRY

Rubus frondosus Bigelow, Fl. Bost. Ed. 2: 199. 1824
Rubus recurvans Blanchard, Rhodora 6: 223. 1904
Rubus arundelanus Blanchard, Rhodora 8: 176. 1906
Rubus philadelphicus Blanchard, Torreya 7: 56. 1907
Rubus brainerdi Rydb., No. Am. Fl. 22: 467. 1. 1913

Stems arched recurving, nearly cylindrical, armed with stout, straight and somewhat recurved prickles, devoid of gland-tipped hairs and bristles; leaves on turions mostly 5-foliolate, of early summer subglabrous above, velvety beneath; the terminal leaflet suborbicular or broadly ovate; racemes 8-12-flowered, glandless; bracts of racemes more or less leafy; drupelets few, large, black, sweet and pulpy; seeds large, about 2½ mm. long.

Pollen about 75% imperfect. Seedlings grown from this species show quite a range of variation as to shape of leaves, serration of leaflets, etc., but not in respect to specific characters.

Time of blooming: June 5 to July 12.

Time of fruiting: July 20 to September 1.

Type station: Boston (Roxbury), Mass.

Distribution: Open fields and hillsides in southern New England. The form *R. recurvans* Blanchard extends further north into Maine, New Hampshire and Vermont.

As grown in the wild the plant is quite confusing to the systematist on account of its behavior under different environmental conditions. Its frondoseness is increased by light and drought and diminished by shade and moisture. Its erectness of growth is likewise effected by environment. A northern form, having narrower leaflets and fewer leafy bracts on racemes, is recognized.

From the horticultural standpoint, this blackberry is by far the most important of all our New England wild species and on account of its plasticity under cultural conditions it ought to be readily improved by plant breeders.

Closely related cultivated varieties are: Bangor, Joy, LaGrange, Ohmer, Sugar Plum, Tory, Ward and Watt. Its hybrids with *R. argutus* and *R. allegheniensis* are also cultivated.

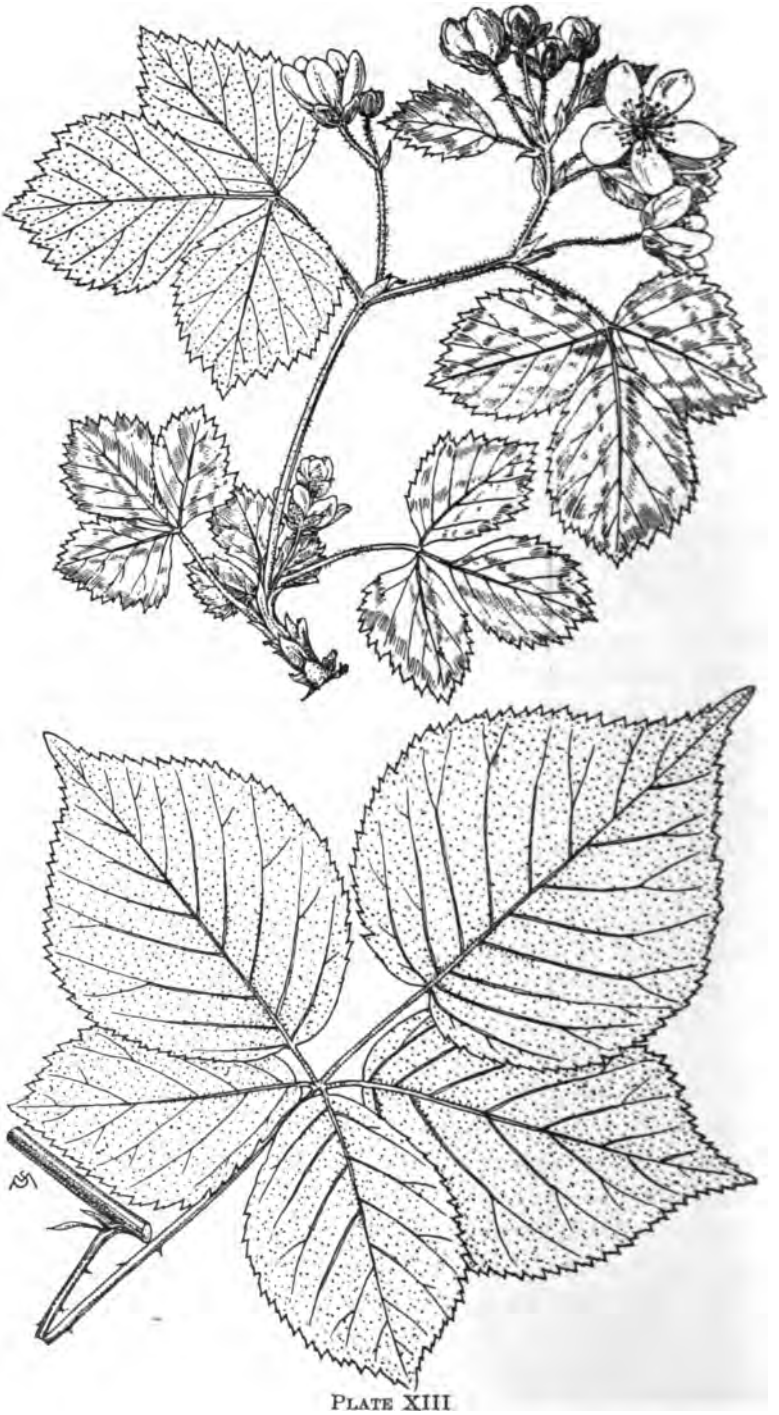


PLATE XIII

R. brainerdi **Rydb.**
Four-fifths natural size.

R. brainerdi Rydb. is a marked illustration of the confusion which has existed in the taxonomic literature of the American Rubi in the past. The type plant from Weybridge, Vt., was first determined by L. H. Bailey as "a small form of *R. nigrobaccus sativus*"—a name by which he designated an imagined wild progenitor of the short-cluster blackberries of cultivation. But based upon no definite type (14), Brainerd (13) in a discussion of the plant to which Bailey had applied this varietal name is accredited with the elevation of this variety to specific rank through a too liberal revision of his manuscript by the editors of Rhodora. Rydberg (3) in order to conform with the rules of priority renamed this hypothetical species and used the Weybridge plant as the type upon which it is based. The plant, however, sent Bailey is but a form of *R. frondosus* Bigelow as shown by a comparison of the plants under cultivation.

PLATE XIV
R. canadensis L.
Two-fifths natural size.

MOUNTAIN BLACKBERRY. THORNLESS BLACKBERRY

Rubus canadensis L. Sp. Pl. 494. 1753

Rubus randii (Bailey) Rydb., Britton Man. 497. 1901

Rubus millspaughii Britton, Bull. Torrey Club 18: 366. 1891. [See Ill. Fl. 2: 279]

Rubus amabilis Blanchard, Rhodora 8: 173. 1906. Not *R. amabilis* Focke. 1905

Rubus amicalis Blanchard, Rhodora 13: 56. 1911

Stems ascending and recurving, sometimes reddish or purplish, glabrous, unarmed or with few rudimentary prickles, gland-tipped hairs and bristles absent; leaves on turions mostly 5-foliolate; leaflets long-acuminate or acute, glabrous on both surfaces; inflorescence a loose cylindrical cymose-raceme, eglandular, tomentulose; drupelets large, juicy and somewhat acid.

Pollen about 85% imperfect. Seedlings do not show any segregation in culture.

Time of blooming: June 10 to July 16.

Time of fruiting: August 20 to September 25.

Type station: Canada.

Distribution: In thickets and along woody borders at higher altitudes throughout New England; sometimes descending into the lower valleys. It is the common blackberry of our mountain woodland.

"The Thornless Blackberry" is nothing but a cultivated form of this species.

PLATE XV
R. elegantulus Blanchard
Two-thirds natural size.

SHOWY-FLOWERING BLACKBERRY
NEEDLE BLACKBERRY

Rubus elegantulus Blanchard, Rhodora 8: 95. 1906

Stems slender, erect, usually reddish, glabrous; plants eglandular throughout; prickles long, needle-like with a broad base, about 4 or 5 to the cm. of cane; leaves on turions mostly 5-foliolate, glabrous on both surfaces; petioles, petiolules and midveins armed with slender recurved prickles; racemes long, sometimes compound, with few short prickles; pedicels obscurely tomentulose; flowers large, showy; drupelets few, large; fruit globose, sweet.

Pollen about 70% imperfect. Seedlings do not seem to segregate in culture.

Time of blooming: June 10 to July 18.

Time of fruiting: August 20 to September 28.

Type stations: Stratton, Vt. and elsewhere.

Distribution: At high altitudes throughout Vermont and New Hampshire.

PLATE XVI

R. vermontanus Blanchard
Two-thirds natural size.

VERMONT BLACKBERRY

Rubus vermontanus Blanchard, Am. Bot. 7: 1. 1904

Rubus nigricans Rydb., Britton Man. 498. 1901 (in part). Not as amended in No. Am. Fl. 22: 476. 1913

Rubus peculiaris Blanchard, Rhodora 8: 174. 1906

Rubus nigricans Rydb., Gray Man. Ed. 7: 491. 1908 as to description.

Stems ascending and recurving, armed with numerous bristle-pointed prickles, about 20 to the cm. of cane; plants eglandular and glabrous throughout; leaves on turions mostly 5-foliolate, glabrous on both surfaces; terminal leaflet about twice as long as wide; cymose-racemes 6-12-flowered, 1-5 from the axil of each leaf; drupelets large, few; fruit globose.

Pollen about 85% imperfect. Seedlings do not segregate in culture.

Time of blooming: June 15 to July 22.

Time of fruiting: August 17 to September 12.

Type station: One and a half miles south of Windham, Vt.

Distributions: Frequent at about 1,000 feet altitude throughout Vermont and New Hampshire.

Although the fruit of this species is small, it is a profuse bearer. No varieties from this species are known to be cultivated for their fruit.

PLATE XVII

R. setosus Bigelow

Three-fourths natural size.

BRISTLY BLACKBERRY

Rubus setosus Bigelow, Fl. Bost. Ed. 2, 198. 1824. Gray Man. 491. 1908.

Rubus hispidus suberectus Peck, Ann. Rep. N. Y. State Mus. 44: 31. 1891. Not *R. suberectus* Anders. 1815

Rubus nigricans Rydb., Britton Man. 498. 1901 (in part). No. Am. Fl. 22: 476. 1913

Stems ascending and recurving, sometimes more or less prostrate, densely covered with retrose bristles, about 40 to the cm. of cane; gland-tipped bristles abundant on stem, petiole, raceme and calyx; leaves of turions mostly 5-foliolate, sometimes trifoliolate, glabrous on both surfaces; inflorescence a corybos cymose-raceme; fruit hemispherical, red; drupelets few.

Pollen about 80% imperfect. Seedlings do not show any segregation of specific characters when grown in culture.

Time of blooming: July 1 to August 1.

Time of fruiting: August 25 to September 22.

Type station: Sudbury, Mass.

Distribution: Throughout New England at high altitudes and in bogs and wet places at lower levels.

This species has very commonly been confused with *R. vermontanus* Blanchard although the two species are very distinct.

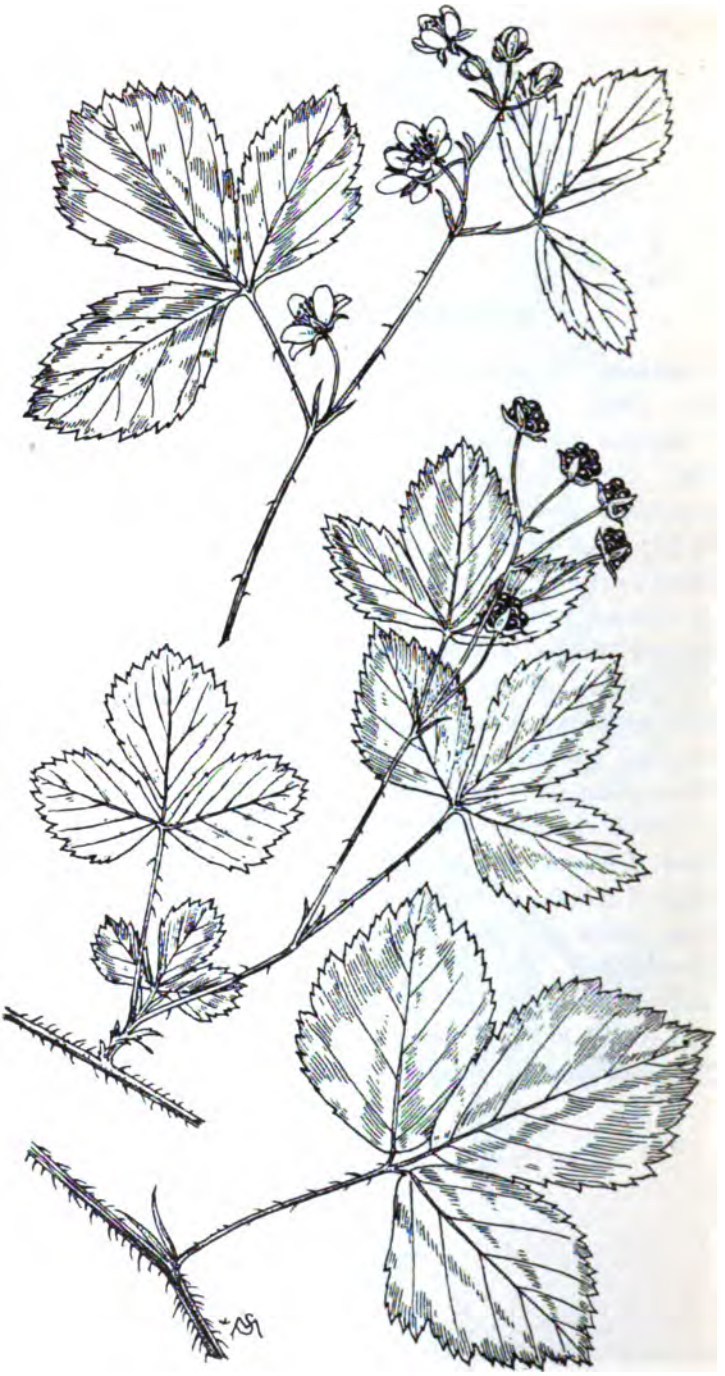


PLATE XVIII

R. hispidus L.

Natural size.

RUNNING SWAMP BLACKBERRY. HISPID BLACKBERRY

Rubus hispidus L. Sp. Pl. 493. 1753

Stems slender, terete, long and trailing, beset with many slender reflex bristles; leaves on turions mostly 3-foliolate; terminal leaflet obovate; leaflets glabrous on both surfaces, smooth, thickish, somewhat shiny above, mostly persistent during the winter; rhachis and pedicels often bristly and even glandular; inflorescence a few-flowered, close cymose-raceme; fruit of few drupelets, reddish-purple; drupelets small; sour.

Pollen about 90% imperfect. Seedlings show very little variation from parent plant.

Time of blooming: July 4 to July 31.

Time of fruiting: August 18 to September 20.

Type station: Canada.

Distribution: Low woods or swampy grounds throughout New England.

This is a unique and interesting species but of no horticultural importance, except in certain crosses with southern forms as *R. floridus* Tratt.

PLATE XIX
R. flagellaris Willd.
Four-fifths natural size.

WHIP BLACKBERRY

Rubus flagellaris Willd., Enum. 549. 1809

Rubus canadensis of Gray Man., Ed. 2. 1857. (Not *R. canadensis* L.)

Rubus procumbens Muhl., Muhl. Cat. 50. 1813

Stems terete, whip-like (often becoming thicker as it grows), trailing widely, often 3-4 meters long, armed with stiff hooked prickles 2-3 mm. long and about 2-5 to the cm. of cane; leaves on turions mostly 3-foliolate, sometimes 5-foliolate; leafllets somewhat sharply serrate, smooth above, slightly hairy beneath especially the veins; terminal leaflet on turions orbicular; pedicels erect, elongate, usually 2-5-flowered; fruit large, black, hemispheric; drupelets 15-30, large.

Pollen about 10% imperfect. Seedlings grown from this species show little or no variation from the parent plant.

Time of blooming: June 6 to July 1.

Time of fruiting: August 1 to September 10.

Type stations: North America.

Distributions: Dry ground in open fields and meadows throughout New England.

R. flagellaris Willd, has received quite different treatments by the various Eubatologists. Bailey (14) considers it a "puzzle" although he reproduces a very excellent photograph of the type specimen which he obtained at Berlin. In the latest editions of Gray's (2) and Britton's (1) manuals it is not even mentioned as a synonym while Rydberg (3) gives it specific rank. Focke in a discussion of the various doubtful forms of dewberries in his final work on *Rubus* asks the following question concerning it: *"Anne forma major robusta R. procumbentis?"* We are confident that what the American botanists have been naming *R. flagellaris* Willd. is nothing but a robust form of *R. procumbens* Muhl. Our cultivated plants of this species answer perfectly to Willdenow's description and his type specimen, which was a garden form, appears to be identical with our cultivated plants of *R. procumbens* Muhl, which have been collected from various parts of New England. We are therefore forced to accept Willdenow's name for our common northern dewberry as it antedates by four years even Muhlenberg's catalog name.

This plant does not seem to have entered very largely into our cultivated dewberries, as its berries are quite inferior to those of *R. baileyanus* Britton and *R. enslenii* Tratt.

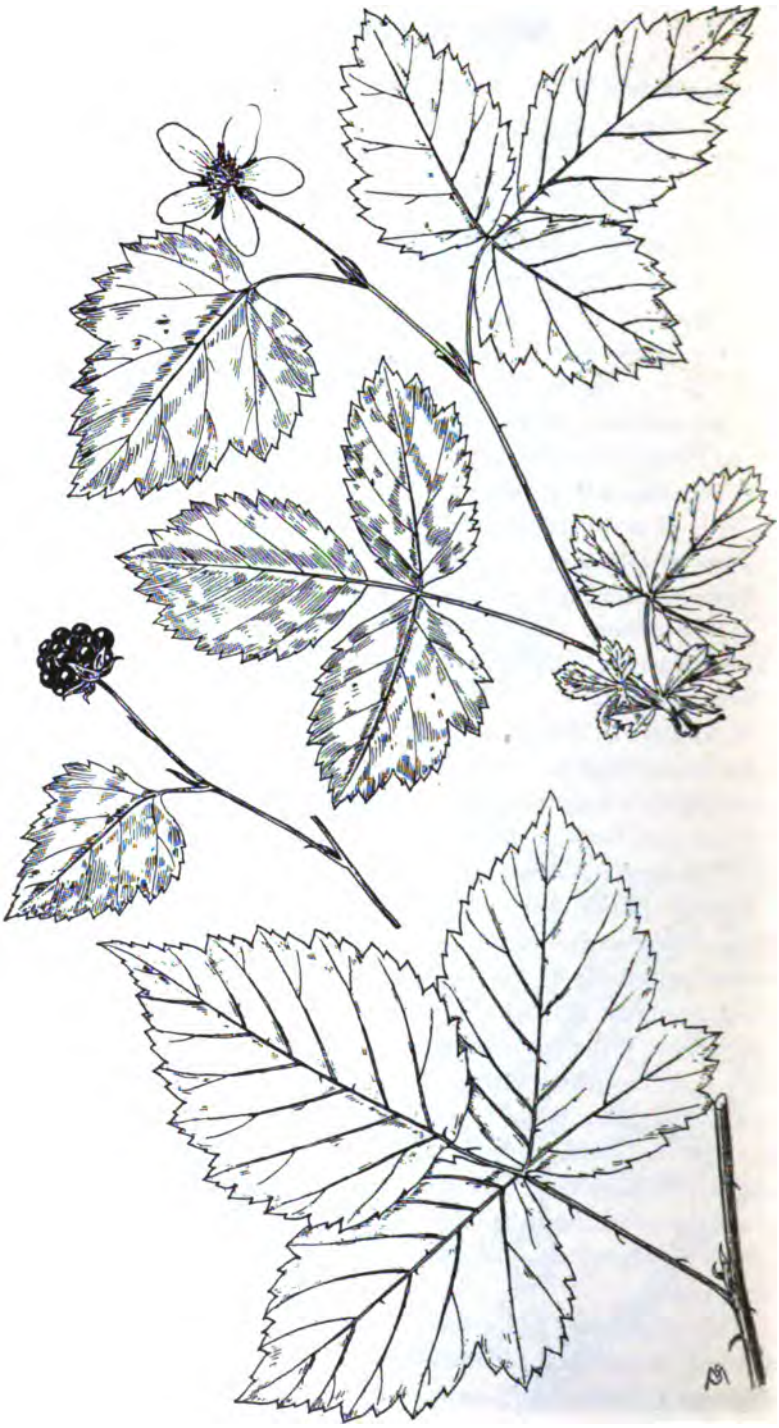


PLATE XX

R. enslenii Tratt.

Two-thirds natural size.

ENSLEN'S BLACKBERRY. DEWBERRY

Rubus enslenii Tratt. Ros. Monog. 3: 63. 1823

Stems terete, slender, trailing, glabrous, sparingly armed with small hooked prickles about 1-2 to the cm. of cane; leaves on turions mostly 3-foliolate; leaflets double-serrate with broadly rounded mucronate teeth, glabrous on both surfaces, ciliolate; flowers mostly solitary; pedicels glandless; fruit large, black, few drupelets.

Pollen about 10% imperfect.

Time of blooming: June 3 to July 1.

Time of fruiting: August 2 to September 1.

Type stations: North America.

Distributions: Open fields and meadows in southern New England, and southward.

Some of the cultivated forms of this species are Chestnut and Eight Ells. Illinois is undoubtedly a cross between this species and *R. frondosus* Bigelow.

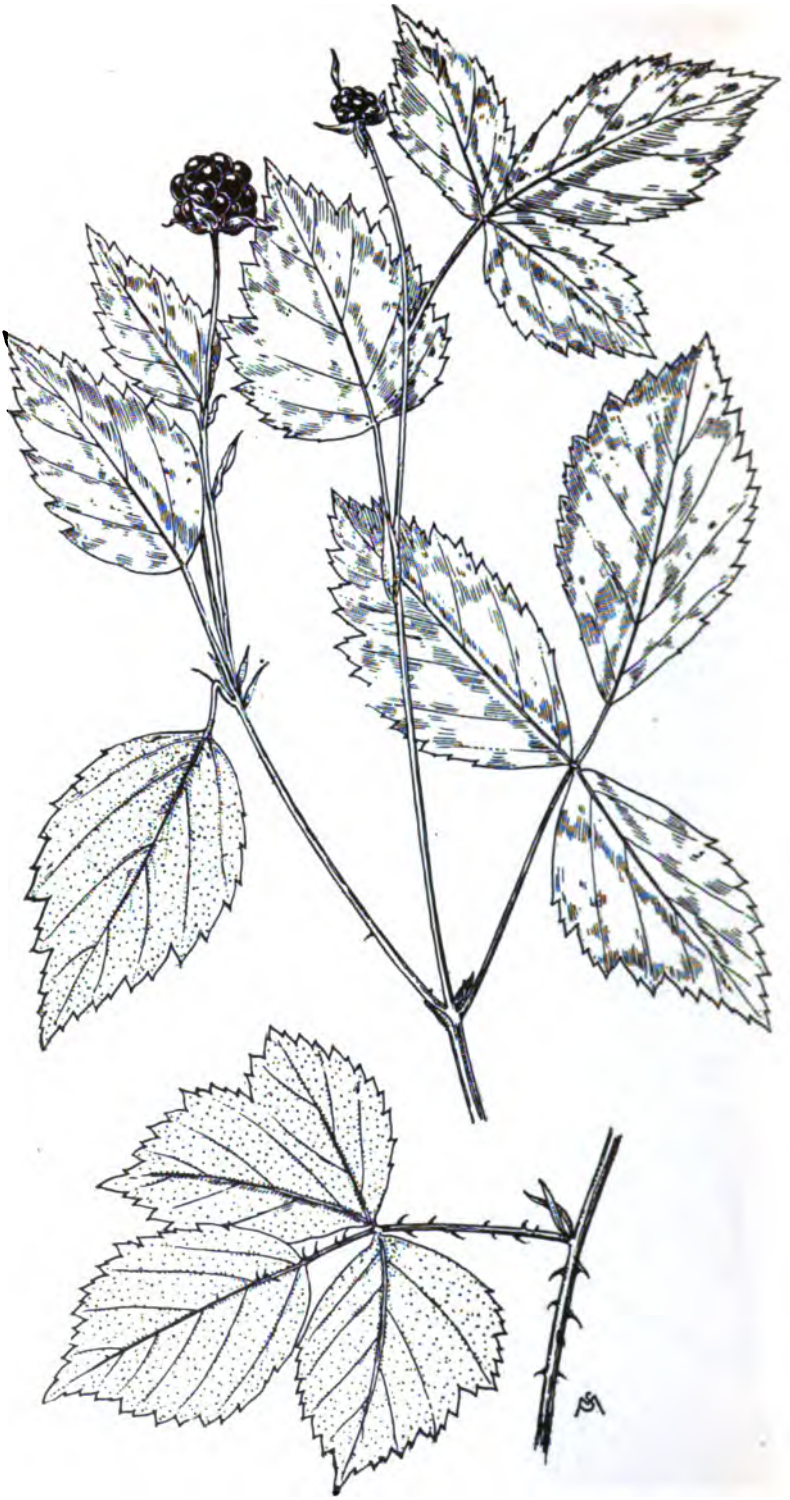


PLATE XXI

R. baileyanus Britton

Four-fifths natural size. An eglandular form.

BAILEY'S BLACKBERRY. DEWBERRY

Rubus baileyanus Britton, Mem. Torrey Club 5: 185. 1894

Rubus villosus humifusus T. & G., No. Am. Fl. 1: 455. 1840. Not *R. humifusus* Weihe. 1825.

Rubus invisus Britton, Bull. Torrey Club 20: 279. 1893. Not *R. canadensis invisus* Bailey. 1891.

Stems terete, trailing, often beset with stalked or sessile glands, sparingly armed with stiff hooked prickles 2-3 mm. long and about 1-3 to the cm. of cane; leaves on turions mostly 3-foliolate; terminal leaflet ovate; leaflets with course broadly rounded mucronate teeth, of early summer pubescent beneath; pedicels erect, elongate, often glandular, usually 1-3-flowered; flowers somewhat large; fruit black, few drupelets; seeds large.

Pollen about 10% imperfect. Seedlings grown from this plant show very little variation.

Time of blooming: May 26 to June 30.

Time of fruiting: July 31 to August 30.

Type station: West Point, N. Y.

Distribution: Dry fields, along fence-rows and open woods throughout New England, except in the extreme north.

The characters of this species are very prominent in a large number of our common cultivated dewberries. From this species have been developed, either directly or indirectly through hybridization, some of our most prized dewberries of cultivation. The probable origin of some of these is indicated as follows: Rathbun, Thompson's Early Mammoth—*R. argutus X baileyanus;* Crandall, Robinson—*R. baileyanus X betulifolius;* Bartel, General Grant, Mammoth, Premo —*R. baileyanus X enslenii;* Austin's, Cox Lucetia—*R. baileyanus X floridus.*

PLATE XXII

R. baileyanus Britton

Four-fifths natural size. A glandular form.

PLATE XXIII

R. allegheniensis X argutus

Two-thirds natural size.

RUBUS ALLEGHENIENSIS X ARGUTUS

Rubus andrewsianus Blanchard, Rhodora 8: 17. 1906
Rubus allegheniensis X *argutus* Bicknell, Bull. Torrey Club 38: 111. 1911

Stems erect, armed with strong, straight, broad-based prickles, mostly glabrous with a few scattered gland-tipped hairs; leaves on turions mostly 5-foliolate, of early summer somewhat pubescent on the lower surface; terminal leaflet oval or obovate; inflorescence bearing gland-tipped hairs; pedicels armed with hooked prickles; seeds large.

Resembles *R. argutus* in having prickles on pedicels, almost glabrous new canes and large seeds; resembles *R. allegheniensis* in having pubescent leaves and glandular inflorescence; the shape of the leaflets, the number of flowers in the raceme and the size and shape of prickles are intermediate.

Pollen about 80% imperfect. Numerous plants grown from the seeds of this hybrid vary towards both parent species.

Collected at the following stations: Weybridge, Vt.; Southington, Conn. (type station); Hague, N. Y.; Milton, Mass.; North Hanover, Mass.; South Duxbury, Mass.; Manomet, Mass.; Indiana (C. C. Deam).

This hybrid is the probable progenitor of the following cultivated varieties: Ancient Britton, Badger, Dorchester, Eldorado, Lovett and Taylor.

PLATE XXIV

R. argutus X frondosus

Two-thirds natural size.

RUBUS ARGUTUS X FRONDOSUS

Rubus jeckylanus Blanchard, Rhodora 8: 177. 1906*

Rubus argutus X *frondosus* Bicknell, Bull. Torrey Club 38: 114. 1911

Stems ascending and recurving, glabrous and glandless, armed with strong, slightly hooked prickles; leaves on turions mostly 5-foliolate, of early summer velvety beneath; the terminal leaflet broadly ovate, petioles and petiolules armed with hooked prickles; racemes leafy-bracted, cymose-corymbose; pedicels armed and often having a few scattered glands; fruit ovoid.

Resembles *R. argutus* in having leafy-bracted inflorescence and broadly ovate leaflets; other characters are intermediate.

Pollen about 60% imperfect.

Collected at Kennebunkport, Me. (type station); also at Brookline, Mass. and from garden at Middlebury, Vt.

This hybrid is the probable progenitor of the following cultivated varieties: Blowers, Erie, Jordan, Kittatinny, Mersereau, Minnewaski and Western Triumph.

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*Named after a fictitious person who lived a double life in a well-known story of Stevenson. The flowering plant is attractive when seen, but atrocious when handled.

PLATE XXV

R. alleghenienſis X elegantulus

Two-thirds natural size.

RUBUS ALLEGHENIENSIS X ELEGANTULUS

Rubus flavinanus Blanchard, Am. Bot. 10: 69. 1906

Stems ascending and recurving, glabrous and bearing a few gland-tipped hairs, armed with slender, hooked prickles with a broad, flattened base; leaves on turions mostly 5-foliolate, of early summer pubescent beneath; terminal leaflet on new canes obovate; petioles glandless, copiously armed with hooked prickles; racemes elongate; petals 1½ cm. long; pedicels very glandular; fruit globose, sweet.

Resembles *R. allegheniensis* in having glands on new canes and inflorescence and somewhat pubescent leaves; resembles *R. elegantulus* in having long, slender prickles, large, showy flowers and sweet, globose fruit; the shape of leaves, number of flowers in racemes and most of the other characters are intermediate.

Pollen about 65% imperfect. Seedlings from this plant vary towards the two parents.

Blanchard describes this plant as a dwarf form solely on account of the condition under which his type specimen grew. Plants from the type station which were transplanted to the plant breeding gardens of the station have developed into large, robust plants.

Collected at the type station, Stratton, Vt.

PLATE XXVI
R. allegheniensis X vermontanus
Four-fifths natural size.

RUBUS ALLEGHENIENSIS X VERMONTANUS

Rubus fraternus, hyb. nov.

Stems ascending and recurving, glabrous and bearing a few gland-tipped hairs, armed with long, slender prickles; leaves on turions mostly 5-foliolate, of early summer pubescent beneath; terminal leaflet on new cane oval or obovate; petioles glandless; often pubescent, armed with hooked prickles; racemes short; pedicels glandular, unarmed; flowers small.

Resembles *R. allegheniensis* in having glands on stems and inflorescence and in having pubescent leaves; resembles *R. vermontanus* in having short, broad racemes and globose fruit; the shape of leaf, number and size of prickles and number of flowers in racemes are intermediate.

Pollen about 60% imperfect.

Collected at the following stations: Stratton, Vt., north of old church (type station); Stratford, N. H. (Fernald).

PLATE XXVII.
R. allegheniensis X setosus
Two-thirds natural size.

RUBUS ALLEGHENIENSIS X SETOSUS

Rubus glandicaulis Blanchard, Rhodora 8: 172. 1906

Stems erect and recurving, armed with strong prickles of varying sizes; stems, petioles, petiolules and inflorescence copiously beset with gland-tipped hairs and bristles; leaves on turions mostly 5-foliolate, of early summer velvety beneath; terminal leaflet oval; racemes elongate, 14-18-flowered; pedicels unarmed, often branched; drupelets large.

Resembles *R. pergratus* in having pubescent leaves and racemes and somewhat broad terminal leaflets; resembles *R. setosus* in having glandular stem and inflorescence; the number and size of prickles, shape of raceme and the number of flowers in racemes are intermediate.

Pollen about 60% imperfect.

Collected at the following stations: Kennebunk, Me. (Blanchard's type station); Eden, Vt.; Stewartstown, N. H. (Fernald).

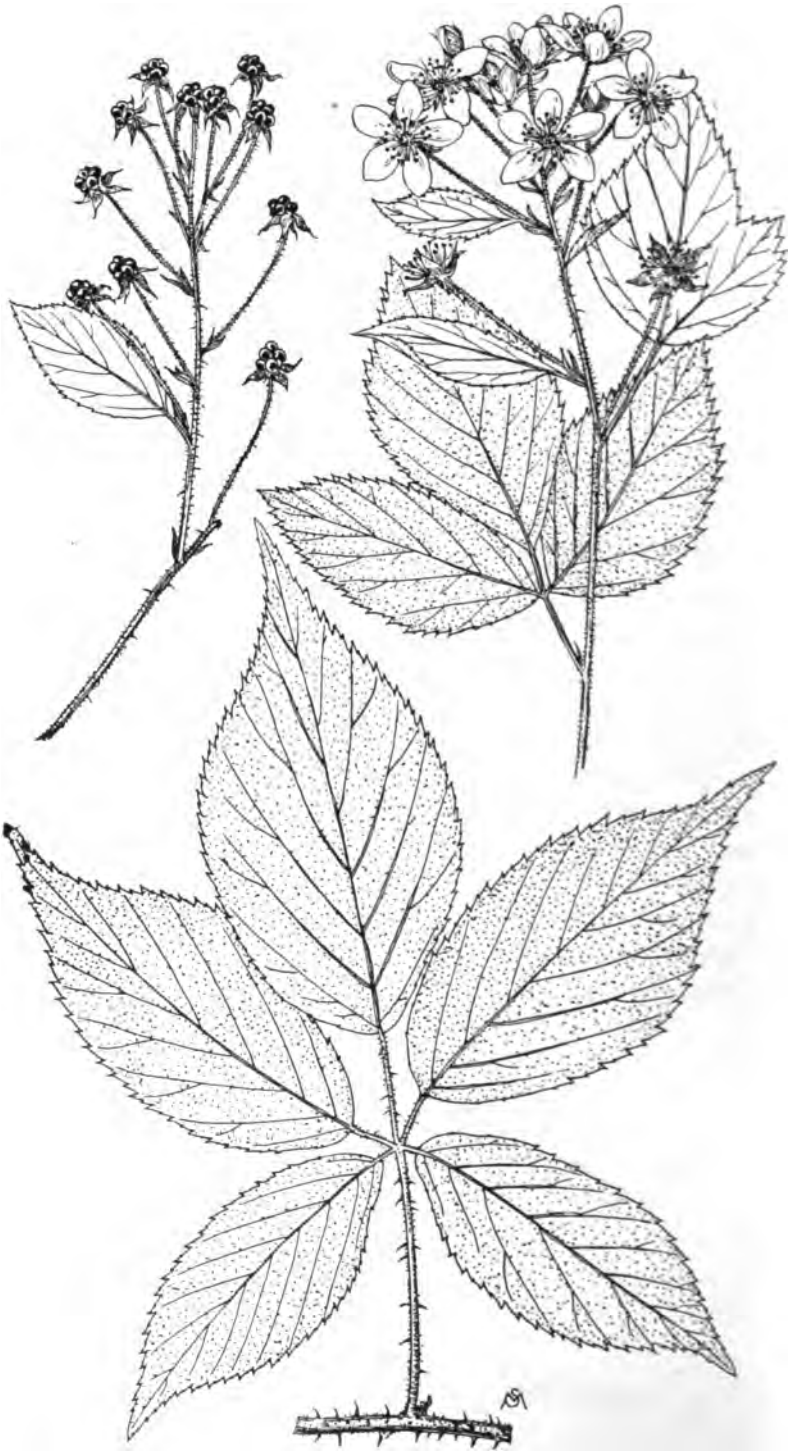

PLATE XXVIII
R. pergratus X setosus
Four-fifths natural size.

RUBUS PERGRATUS X SETOSUS

Rubus frondisentis Blanchard, Torreya 6: 119. 1906

Stems erect and recurving, armed with weak prickles of varying sizes; stems, petioles, petiolules and inflorescence copiously beset with gland-tipped hairs; leaves on turions mostly 5-foliolate, of early summer velvety beneath; terminal leaflet oval; racemes short, 8-11-flowered, very pubescent; pedicels unarmed; flowers often nearly sterile; seeds large.

Resembles *R. allegheniensis* in having pubescent leaves and inflorescence and a many-flowered raceme; resembles *R. setosus* in having bristles on the stem and inflorescence; the number and size of prickles, the size and shape of leaf and the shape and size of fruit are intermediate.

Pollen about 10% imperfect. Seedlings from this plant are very uniform and seem to breed true to the type.

Collected at the following stations: Townshend, Vt. (type station); Berkshire, Vt.; Stratton, Vt.; Stratford, N. H. (Fernald); Colebrook, N. H. (Fernald); Northumberland, N. H. (Fernald); Stewartstown, N. H. (Fernald).

PLATE XXIX
R. frondosus X setosus
Two-thirds natural size.

R. FRONDOSUS X SETOSUS

Rubus abbrevians Blanchard, Torreya 6: 235. 1906

Stems ascending and recurving, terete, glabrous, armed with numerous weak prickles of varying lengths; new canes and inflorescence glandular; leaves on turions mostly 5-foliolate, of early summer pubescent beneath; leaflets broadly ovate, lower leaflets nearly sessile; racemes short, 8-12-flowered; pedicels copiously beset with gland-tipped hairs and bristles; drupelets large; fruit globose.

Resembles *R. frondosus* in having broadly ovate and pubescent leaflets; resembles *R. setosus* in having stems and inflorescence glandular and setaceous prickles; other characters are more or less intermediate.

Pollen about 10% imperfect. Seedlings grown from the seeds of selfed flowers of this plant vary very little from the mother plant.

Collected at the following stations: Stevens's Hill, North Windham, Vt. (type station); Stratton, Vt.; West Dummerston, Vt.; Townshend, Vt.; Stratford, N. H. (Fernald); North Woodstock, N. H. (Fernald); Thornton, N. H. (Fernald).

PLATE XXX

R. canadensis X setosus

Two-thirds natural size

RUBUS CANADENSIS X SETOSUS

Rubus junceus Blanchard, Rhodora 8: 215. 1906

Stems weak, erect and recurving, becoming more or less prostrate with age, armed with weak, setaceous prickles grading into bristles and gland-tipped hairs; leaves on turions mostly 5-foliolate, glabrous on both surfaces, terminal leaflet oval, lower leaflets nearly sessile; petiole and petiolules armed and glandular; rhachis villous and somewhat glandular; racemes short; pedicels 2-5 cm. long; fruit globose.

Resembles *R. canadensis* in having a villous rachis and oval leaflet; resembles *R. setosus* in having glands and setaceous prickles on cane, petioles and inflorescence and weak canes; the shape of raceme, size of flowers and other characters are intermediate.

Pollen about 85% imperfect.

Collected at the following stations: Kennebunk, Me. (type station); Stratton, Vt.; South Wardsboro, Vt.; West Wardsboro, Vt.; Wallingford, Vt.; North Woodstock, N. H.; Plymouth, N. H. (Fernald); Errol, N. H. (Fernald); Lincoln, N. H. (Fernald); Gorham, N. H. (Fernald); Woodstock, N. H. (Fernald); Thornton, N. H. (Fernald); Laconia, N. H. (Fernald); Gilford, N. H. (Fernald).

PLATE XXXI

R. allegheniensis X hispidus

Four-fifths natural size.

RUBUS ALLEGHENIENSIS X HISPIDUS

Rubus permixtus Blanchard, Torreya 6: 117. 1906

Stems recurving and soon prostrate, armed with numerous straightish prickles of unequal lengths; cane, petioles, petiolules and racemes beset with gland-tipped hairs and bristles grading into prickles; leaves on turions mostly 5-foliolate, of early summer velvety beneath; terminal leaflet about twice as long as wide; racemes 8-16-flowered, elongate, not leafy-bracted; fruit black.

Resembles *R. alleghenienses* in having mostly 5-foliolate leaves on turions, pubescent leaves, glandular cane and inflorescence, straightish prickles and black fruit; resembles *R. hispidus* in having trailing stems beset with bristles; the shape of raceme, number of flowers in racemes, shape of leaflets and other characters are more or less intermediate.

Pollen about 50% imperfect. Seedlings grown from the seed of this hybrid when selfed do not revert to the parent types.

Collected at the following stations: Westminster, Vt. (type station); Putney, Vt.; Burlington, Vt.; Walpole, N. H.; Burlington Co., N. J. (Darrow); Cambridge, N. Y. (Brainerd).

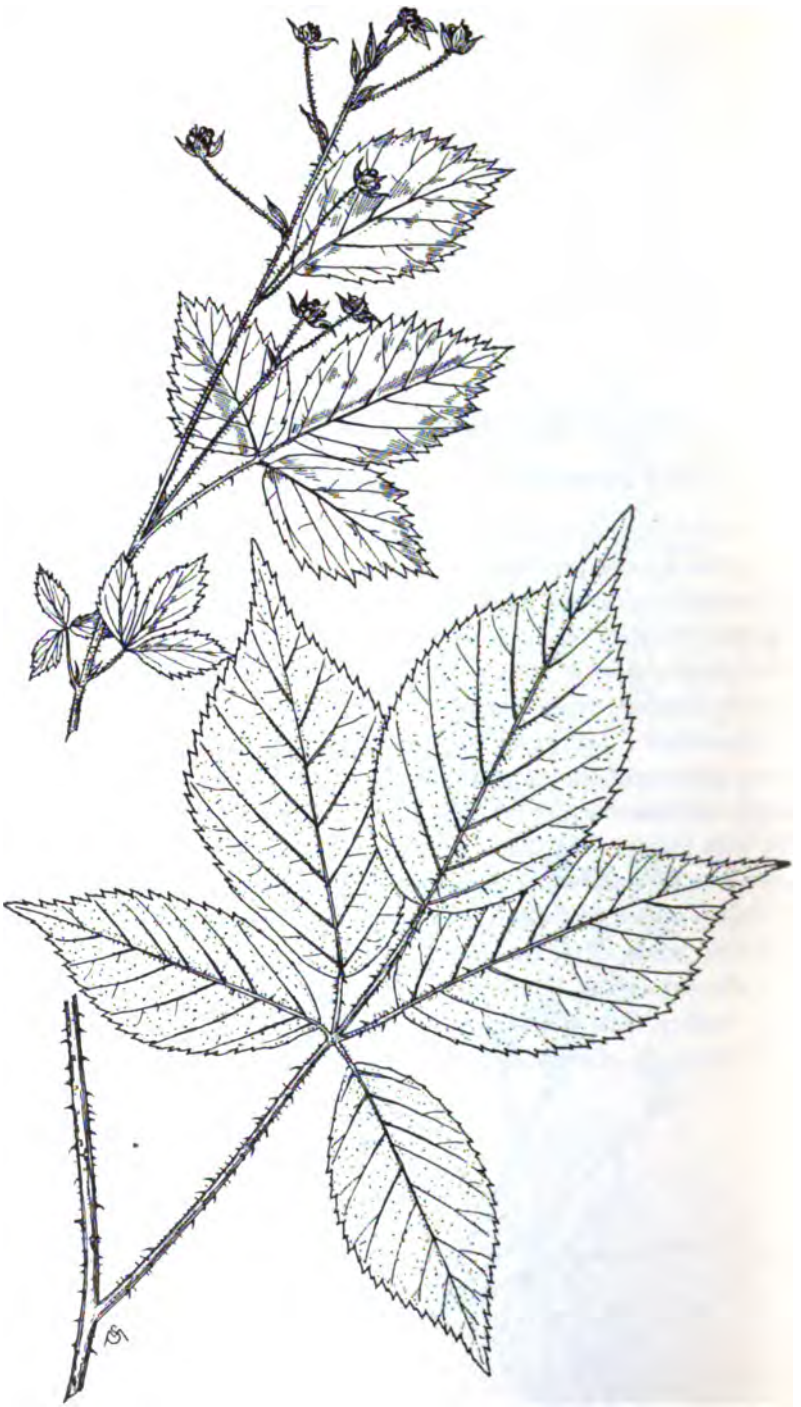

PLATE XXXII

R. allegheniensis X flagellaris

Eight-elevenths natural size.

RUBUS ALLEGHENIENSIS X FLAGELLARIS

Rubus elongatus, hyb. nov.

Stems prostrate, young shoots somewhat ascending, armed with hooked prickles, beset with gland-tipped hairs of uniform length; leaves on turions mostly 5-foliolate, of early summer velvety beneath; petiole and petiolules armed and glandular; terminal leaflet about twice as long as wide; inflorescence glandular; racemes 6-10-flowered; fruit small.

Resembles *R. alleghenienses* in having glandular cane and inflorescence and 5-foliolate leaves on turions; resembles *R. flagellaris* in having hooked prickles and prostrate stems; the amount of pubescence on leaves, shape of leaflets, shape of racemes and number of flowers in racemes are intermediate.

Pollen about 75% imperfect.

Collected at Cambridge, N. Y. (type station).

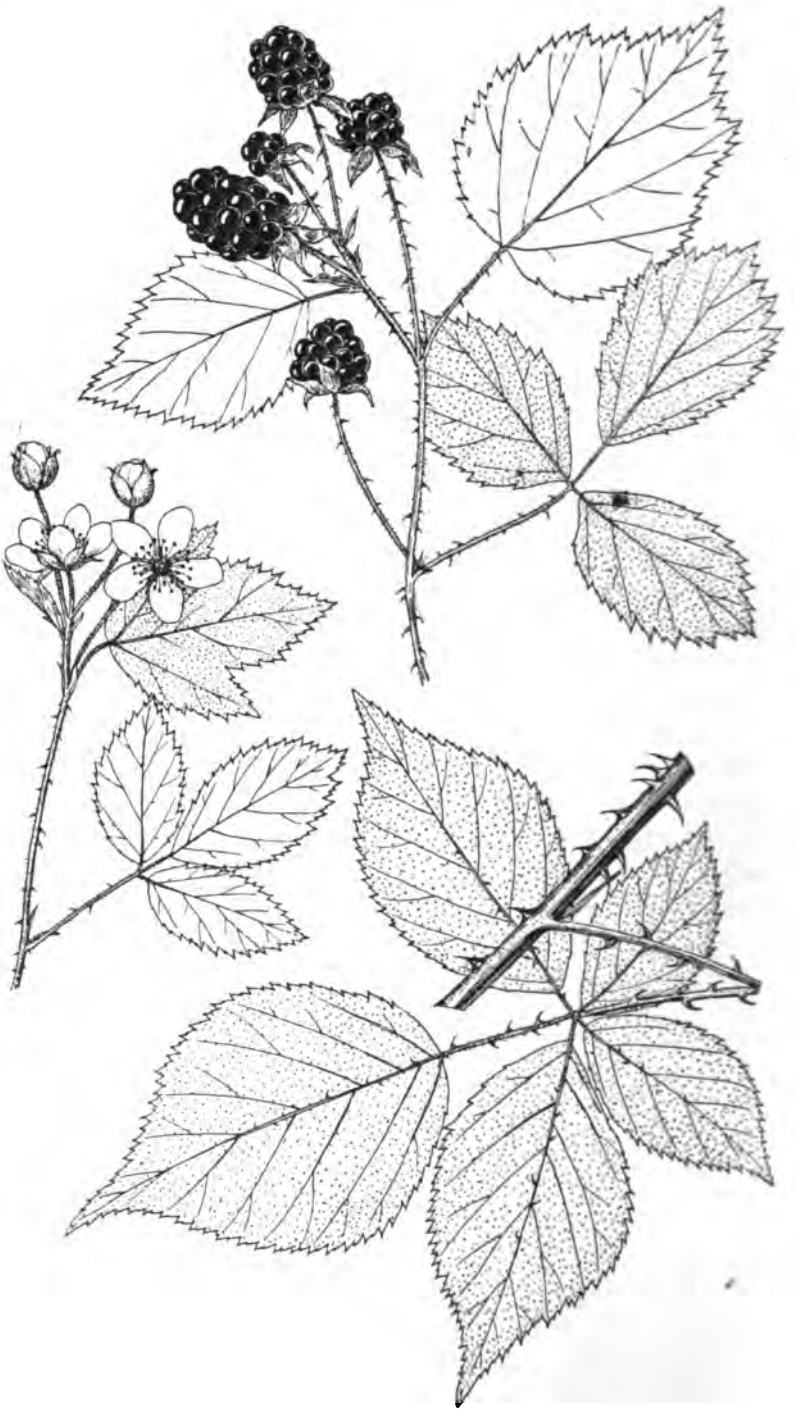

PLATE XXXIII
R. argutus X flagellaris
Two-thirds natural size.

RUBUS ARGUTUS X FLAGELLARIS

Rubus multispinus Blanchard, Torreya 7: 7. 1907

Stems recurving and soon becoming prostrate, armed with large, hooked prickles, about 5 to the cm. of cane; cane leaves and inflorescence glandless; leaves on turions mostly 5-foliolate, often 3-foliolate, of early summer somewhat pubescent beneath; terminal leaflet broadly ovate; racemes few-flowered, corymbose; pedicels pubescent, armed with hooked prickles; fruit large, short, cylindrical, black.

Resembles *R. argutus* in having mostly 5-foliolate leaves on turions, armed pedicels and pubescent leaves; resembles *R. flagellaris* in having procumbent stems and broadly ovate leaflets on new canes; the shape of raceme, number of flowers in racemes and the shape and size of fruit are intermediate. The prickles are larger than those of either of the parent plants but have the shape of those of *R. flagellaris*.

Pollen about 65% imperfect.

Collected at the following stations: Rocky Point, R. I. (type station); Rehoboth, Mass.; South Duxbury, Mass.; Michigan City, Ind. (Deam).

PLATE XXXIV

R. baileyanus X frondosus

Seven-elevenths natural size.

RUBUS BAILEYANUS X FRONDOSUS

Rubus arenicola Blanchard, Rhodora, 8: 170. 1906

Stems recurving and soon becoming prostrate, glabrous, armed with straightish prickles about 5 mm. long; leaves on turions mostly 5-foliolate, often 3-foliolate, of early summer pubescent beneath; terminal leaflet orbicular; inflorescence corymbose, 4-8-flowered, lower flowers leafy-bracted; pedicels pubescent and glandular; fruit large, globose, black.

Resembles *R. baileyanus* in having prostrate stems and somewhat glandular inflorescence; resembles *R. frondosus* in having on turions 5-foliolate leaves, straightish prickles and orbicular terminal leaflets; the number of prickles on stem, the amount of pubescence on leaves and inflorescence, number of flowers in raceme, size and shape of fruit and most other characters are intermediate.

Pollen about 80% imperfect.

Collected at the following stations: Kennebunk, Me. (type station); Plymouth, Mass.; Natick, Mass. (Darrow).

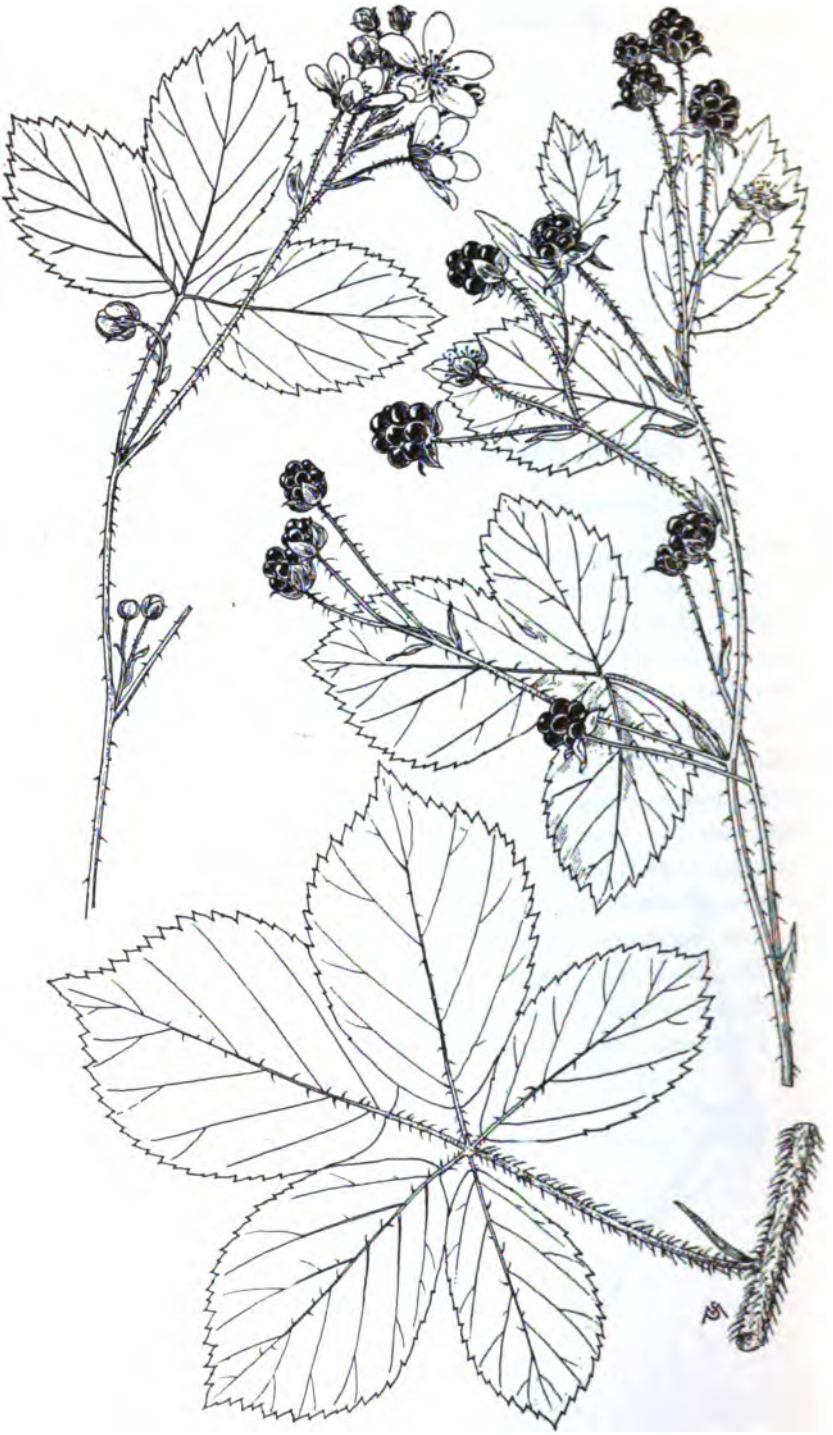

PLATE XXXV

R. hispidus X setosus

Four-fifths natural size.

RUBUS HISPIDUS X SETOSUS

Rubus jacens Blanchard, Torreya 6: 147. July, 1906
Rubus trifrons Blanchard, Am. Bot. 11: 11. Sept., 1906

Stems prostrate, terete, beset with numerous bristles grading into gland-tipped hairs, simple hairs absent; leaves on turions 5-foliolate, in some plants 3-foliolate, glabrous on both surfaces, frequently persistent through the winter; petioles, petiolules and midveins beset with bristles and gland-tipped hairs; terminal leaflet on turions obovate; inflorescence a cymose-raceme, often branched; pedicels slender, glandular, sparsely beset with weak bristles; flowers small; fruit globose; drupelets few, large; seeds large.

Resembles *R. hispidus* in having prostrate stems; resembles *R. setosus* in having sometimes 5-foliolate leaves on turions; the number and shape of bristles, number of gland-tipped hairs, shape of inflorescence, shape of terminal leaflet on turions and most other characters are intermediate.

Pollen about 85% imperfect. Numerous seedlings have been grown from both the 3-foliolate and the 5-foliolate type of this hybrid and in all cases they resemble in most respects one of the parent species.

Collected at the following stations: Alstead, N. H. (Blanchard's type station for *R. jacens;* West Wardsboro, Vt. (Blanchard's type station for *R. trifrons*); Stratton, Vt.; Townshend, Vt.; Westminster, Vt.; Marlboro, Vt.; Burlington, Vt.; Berkshire, Vt.; Ripton, Vt.; Troy, N. H.; Woodstock, N. H. (Fernald); Thornton, N. H. (Fernald); Lincoln, N. H. (Fernald); Gorham, N. H. (Fernald); Gilford, N. H. (Fernald); Lancaster, N. H. (Fernald).

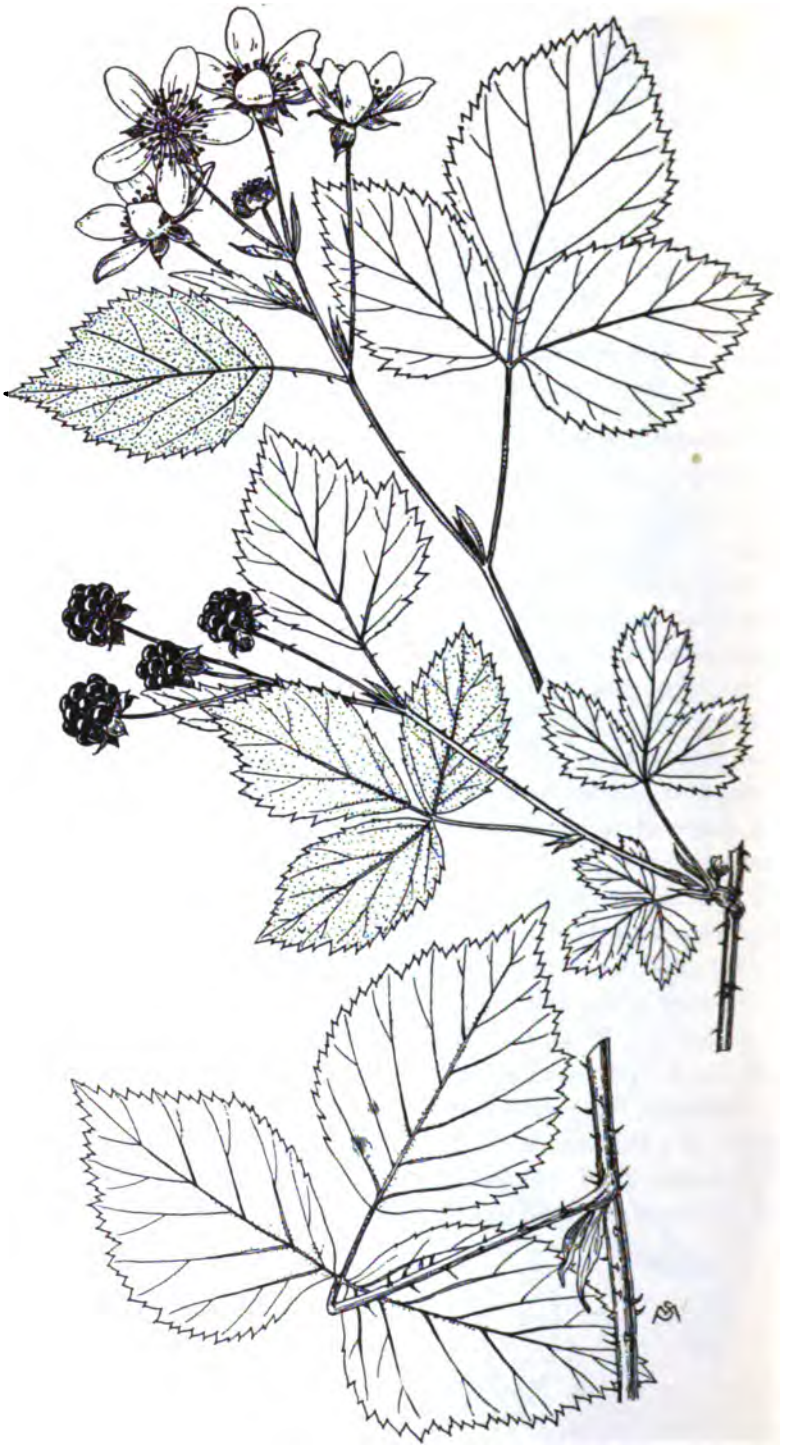

PLATE XXXVI
R. baileyanus X flagellaris
Eight-elevenths natural size.

RUBUS BAILEYANUS X FLAGELLARIS

Rubus invisus (Bailey) Britton, Mem. Torrey Club 4: 115. 1893
Rubus geophilus Blanchard, Rhodora 8: 148. 1906

Stems trailing, 6-12 feet long, glabrous, armed with hooked prickles; cane, leaves and inflorescence glandless; leaves on turions 3-foliolate, of early summer sparsely pubescent beneath, lower leaflets sessile; petiole armed; raceme corymbose, 4-6-flowered; pedicels slightly pubescent, armed with a few scattered prickles; flowers large; fruit globose, black; seeds large.

Resembles *R. baileyanus* in pubescence; resembles *R. flagellaris* in number of prickles on stem and number of flowers in raceme; the shape of leaflets, size of prickles and most other characters are intermediate.

Pollen about 15% imperfect.

Type station: Ithaca, N. Y.

Collected at the following stations: North Hero, Vt.; Burlington, Vt.; Plymouth, Mass.; South Duxbury, Mass.; Rocky Point, R. I.

Following is a list of additional hybrids or suspected hybrids which are found in New England together with a list of the stations where these forms have been collected. Wherever any of these forms have been described as species their binomial is always cited.

Rubus allegheniensis X baileyanus

Stations: Martha's Vineyard, Mass.; Long Island, N. Y.

Rubus allegheniensis X canadensis

Rubus orarius Blanchard, Rhodora 8: 169. 1906

Stations: Stratton, Vt.; Ripton, Vt.

Rubus allegheniensis X frondosus

Stations: Townshend, Vt.; Stratton, Vt.; Walpole, N. H.; Marshall County, Ill.; Indiana (C. C. Deam).

This hybrid is the probable progenitor of the following cultivated varieties: Agawan, Barnard, Erskine Park, Jumbo, Lawton, Snyder, Stone and Wachusett.

Rubus allegheniensis X pergratus

Stations: North Hero, Vt.; West Wardsboro, Vt..

Rubus argutus X canadensis

Rubus amnicola Blanchard, Rhodora 8: 170. 1906

Station: Kennebunk, Me. (type station).

Rubus argutus X enslenii

Rubus ostryifolius Rydberg, Britton Man., 497

Station: Atlantic Highlands, N. J. (type station).

Rubus argutus X hispidus

Station: Hewlett, L. I.

Rubus argutus X setosus

Rubus ascendens Blanchard, Rhodora 9: 9. 1907

Station: Southington, Conn. (type station).

Rubus argutus X vermontanus

Station: Springfield, Mass.

Rubus baileyanus X enslenii

Stations: North Hero, Vt.; Butler's Island, Lake Champlain; Rutland, Vt.; Fair Haven, Vt.; West Wardsboro, Vt.; Walpole, N. H.; Cold River Station, N. H.; Rocky Point, R. I.; South Duxbury, Mass.; Boston, Mass.; Plymouth, Mass.; Rehoboth, Mass.

This hybrid is the probable progenitor of the following cultivated vareties: Bartel, General Grant, Mammoth and Premo.

Rubus baileyanus X canadensis

Rubus multiformis Blanchard, Rhodora 8: 179. 1906 (in part).

Station: Kennebunk, Me.

Rubus baileyanus X hispidus

Stations: West Wardsboro, Vt.; Rocky Point, R. I.; South Duxbury, Mass.; Nantucket Island, Mass. (Bicknell); Woodmere, Long Island, N. Y. (Bicknell); Cypress Hills, Long Island, N. Y.

Rubus baileyanus X setosus

Rubus semisetosus Blanchard, Rhodora 9: 8. 1907

Stations: Plainville, Conn. (type station); Southington, Conn. (Andrews).

Rubus canadensis X elegantulus

Stations: Londonderry, Vt.; Stratton, Vt.

Rubus canadensis X flagellaris

Rubus multiformis Blanchard, Rhodora 8: 179. 1906 (in part)

Station: Kennebunk, Me.

Rubus canadensis X frondosus

Rubus recurvans var. *subrecurvans* Blanchard, Rhodora 8: 152. 1906

Stations: Kennebunkport, Vt. (type station); West Wardsboro, Vt.; Wallingford, Vt.

Rubus canadensis X pergratus

Stations: Burlington, Vt.; Stratton, Vt.; West Wardsboro, Vt.; Londonderry, Vt.; South Londonderry, Vt.; Jamaica, Vt.; Leicester, Vt.; Berkshire, Vt.; Berkshire Center, Vt.; North Windham, Vt.

Rubus canadensis X vermontanus

Stations: Stratton, Vt.; West Wardsboro, Vt.; Ripton, Vt.; Troy, N. H.

Rubus elegantulus X vermontanus

Stations: Stratton, Vt.; West Wardsboro, Vt.; North Windham, Vt.; Stratford, N. H. (Fernald).

Rubus elegantulus X frondosus var. **recurvans**

Stations: Stratton, Vt.; West Wardsboro, Vt.

Rubus elegantulus X setosus

Rubus groutianus Blanchard, Am. Bot. 10: 108. June, 1906

Stations: West Wardsboro, Vt. (type station); Stratton, Vt.

Rubus enslenii X flagellaris

Station: Nantucket, Mass. (Bicknell).

Rubus enslenii X frondosus

Stations: Nantucket, Mass. (Bicknell); Fairmount, Ind. (C. C. Deam).

The "Illinois" in cultivation is probably to be associated with this hybrid.

Rubus enslenii X hispidus

Station: Nantucket, Mass. (Bicknell).

Rubus enslenii X setosus

Station: Long Island, N. Y.

Rubus flagellaris X frondosus

Rubus plicatifolius Blanchard, Rhodora 8: 149. 1906

Stations: Burlington, Vt.; Middlebury, Vt.; Dummerston, Vt.; Essex, Vt.; Kennebunk, Me.

Rubus flagellaris X hispidus

Stations: Nantucket, Mass.; Long Island, N. Y.

Rubus flagellaris X setosus

Rubus tardatus Blanchard, Rhodora 8: 124. 1906

Station: Kennebunk, Me.

Rubus frondosus X vermontanus

Stations: Manchester, Vt.; Williamsville, Vt.

Rubus hispidus X vermontanus

Rubus cubitans Blanchard, Torreya 6: 148. 1906

Stations: Westminster, Vt. (type station); Stratton, Vt.; West Wardsboro, Vt.

Rubus pergratus X vermontanus

Station: Eden, Vt.

Rubus setosus X vermontanus

Rubus vermontanus var. *viridifolius* Blanchard

Stations: Stratton, Vt.; West Wardsboro, Vt.; Townshend, Vt.; Rutland, Vt.; Leicester, Vt.; Banks of Lake Victoria, Ont.

Additional Forms of Doubtful Status

Rubus cuneifolius Pursh, Fl. Am. 347. 1814.
Rubus biformispinus Blanchard, Rhodora 8: 178. 1907.
Rubus rossbergianus Blanchard, Rhodora 9: 7. 1907.
Rubus semierectus Blanchard, Rhodora 8: 156. 1906.
Rubus recurvicaulis Blanchard, Rhodora 8: 153. 1906.

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MARCH, 1921 BULLETIN 218

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

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BLACKBERRIES OF NEW ENGLAND— GENETIC STATUS OF THE PLANTS

By A. K. PEITERSEN

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1921

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BULLETIN 218: BLACKBERRIES OF NEW ENGLAND—GENETIC STATUS OF THE PLANTS

By A. K. Peitersen*

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*Dr. Ezra Brainerd was associated with Dr. Peitersen during the entire period in which the experimental work reported in this bulletin was under way. His assistance in the field and in the experimental garden was invaluable. His help in naming the individual plants used in the experiments add much to the scientific value of the work.

Dr. Brainerd's knowledge of New England plants gained by years of field study and by extensive experimental work has made him the leading scientific systematic botanist of the genera which he has studied. Hence one can feel certain that the plants used in all the work reported in this bulletin were correctly named.

Dr. Brainerd has been a constant help and inspiration throughout the work and only his modesty keeps us from publishing his name as a joint author.

Bulletin 217 of publications of this Station gave a summary of the work which has been accomplished by the many able workers who have published the results of their labor on the difficult problem of the systematic status of Rubus. These studies followed the ordinary

methods of the systematic botanists and led to the most varied conclusions. One does not question the ability of the men who have so faithfully studied this and the other genera of plants, nor does one underrate the value of their work nor the indispensable manuals which they have published, but one does question the "finality of the conclusions" drawn from results obtained by this method. This method necessarily has led to the recognition of so-called "authorities" on the different genera to whom material may be sent for naming. These "authorities" name these plants "by their systematic intuition" gained by long acquaintance with the genus in question. Occasionally there are two authorities in the same field and sometimes they seem to be almost arbitrary in their decisions.

One cannot be surprised that the methods of the systematist has led to confusion in polymorphic genera like Rubus, Cratægus, etc., when one knows that the key published in one of the manuals was made by laying all herbarium material on tables and matching the plants. One would not criticize this method if it is recognized as preliminary work and not taken seriously, but it must be understood that no amount of "systematic intuition" or "prestige as an authority" on Rubus can detect the variations which are due to environment from those which may be of value in a scientific systematic study of the genus. Such preliminary work must be continued, but it is at most only pioneer work and must be subject to revision by the results of carefully conducted experimental work. An herbarium without a botanical garden can add little to our knowledge of the laws of plant development.

The work reported in Bulletin 217 and the present bulletin is an attempt to correlate years of field work with experimental work in garden and greenhouses. Wild plants have been collected, grown under similar conditions, environmental variations evaluated, hereditary factors studied through the segregation of natural hybrids and the production of similar hybrids by artificial crossing, etc. It has been shown that a species which responds to both the recognized systematic and to the genetical criteria for species may arise as the result of hybridization. This shows that hybridization is a potent factor in evolution.

Such experimental work is of the greatest importance and should be used in revising the present manuals. Would that some young man might be induced to undertake such a study of Gratægus!

GEORGE P. BURNS.

SCOPE OF THE WORK

During the summer of 1914 this Station began a series of experiments aiming at the solution of the then perplexing problem of the origin of the many varieties and forms of wild blackberries. At that time it occurred to the writer that data bearing upon this question might have a twofold significance.

First, it might lead to a better and more uniform systematic treatment of the plants in this very polymorphic group. As is stated in Bulletin 217 of this Station, June, 1920, the confused and highly inconsistent treatment accorded this group of plants by the various systematists is in itself excellent evidence of the lack of definite data concerning the origin of many of these doubtful forms. If, therefore, we have succeeded in presenting evidence which will result in a more uniform systematic treatment of the New England wild blackberries, our aim in this respect will have been fully realized.

Second, it was hoped that by an intensive study of the genetic status of the plants in this very variable sub-genus, additional data might be secured which would throw some light upon the evolutionary development of plants in general. It had already been shown experimentally in genera like Viola (Brainerd), and others that natural hybridization occurs frequently. Based only upon systematic differences, Bicknell (2) and others had already named and described a number of wild hybrids of New England blackberries. Part of this work was carried on with the definite aim of either proving or disproving the supposition that blackberries interbreed quite frequently in the wild. It must also be noted in this connection that nearly all of the cultivated varieties of blackberries have quite recently originated from wild forms. Some knowledge of the origin of these forms, therefore, becomes not only important from a purely theoretical point of view but is also fundamental in regard to any future horticultural experimentation aiming at the improvement or production of new varieties.

From extensive field studies it soon became evident that much of the variation in the vegetative characters of these plants was due to external factors. For this reason, the first part of the data presented in the following pages will deal exclusively with such variations. Special attention was also given to the study of sterility occurring within this group, since sterility is unquestionably somewhat correlated with hybridity of origin. The behavior of plants grown from the seed of selfed flowers as well as those grown from the seed of artificially

crossed flowers were studied with the expectation that it would throw further light upon the important question of their origin.

General Characters of the Blackberries

All New England forms of blackberries have perennial roots and biennial stems; the stems develop the first year and die the second season after flowering and fruiting. The stems range from weak trailers to erect canes from two to three meters high. Their leaves are palmately compound, having as a rule five more or less stalked leaflets, but in some of the dewberry types those of the second year's cane as well as of the first year's cane are trifoliolate or occasionally unifoliolate. Their flowers are born on a more or less contracted cymose-raceme, the terminal flower opening first. The fruit consists of partly cohering drupelets which at maturity break off with the fleshy receptacle. The canes and inflorescence are variously covered with simple hairs, gland-tipped hairs and prickles.

Variations as Shown by Plants Growing Wild and Those Growing Under Cultivation

The ordinary fluctuating variations, such as the difference in size and shape of leaflets, length of petiole, number of flowers on raceme and differences in other quantitative characters, are familiar to all students of Rubus. There are, however, certain characters which are universally used as a means for distinguishing one species from another which deserves special attention. These are the presence and absence of simple hairs; glandular hairs and prickles; the manner of stem growth, *i. e.*, trailing or erect; the number of leaflets in a leaf; and the tendency of the autumn stems to tip.

Seasonal variations are very pronounced in some species of blackberries. Thus, for example, in most quinquifoliate varieties the early leaves of spring and the late leaves of autumn are nearly always trifoliate or at least show a tendency to develop three leaves instead of five. Similarly in the pubescent species the vernal leaves may be densely pubescent while the leaves of late summer and autumn are sometimes almost glabrous. *R. frondosus* Bigelow is a good illustration of this type of variation.

Some species such as *R. hispidus* L. are noted for their habit of profuse tipping in late autumn. This, however, is a relative character as all blackberries—at least New England species—will tip if grown

under favorable conditions for doing so. Even the high-bush blackberry—*R. allegheniensis* Porter—is no exception to this rule.

The manner of stem growth is another character which is greatly emphasized in distinguishing the different species. In order to test the stability of this character, plants of *R. allegheniensis* Porter, *R. setosus* Bigelow, *R. frondosus* Bigelow, and *R. hispidus* L. were grown under three different light conditions, namely, full shade, half shade, and no shade. Full shade was obtained by covering plots with lath nailed on a frame as close together as they would permit when moist; half shade by covering plots with a frame similar to that used for full shade except that every other lath was removed; and no shade by using no covering whatsoever.

Although no definite measurements were made, it was very noticeable that the plants in full shade and half shade grew more erect than the corresponding plants in no shade, the latter showing a very marked tendency to trail. This was especially true in the case of the reclining forms such as *R. frondosus* Bigelow and *R. setosus* Bigelow. Plate I. shows this response to light in the manner of growth in *R. frondosus* Bigelow (plant No. 17-5). The erect cane in the center, which is the old cane, grew in the shade while the trailing stems grew the following year in no shade.

There occur on the blackberries several protodermal or epidermal outgrowths which, according to their various form and size of development, are termed prickles, stalked glands or glandular hairs, gland tipped bristles, and simple hairs (plates II to V, inclusive). The importance assigned to these structures as a means for identification of different species makes a consideration of their development of the utmost importance.

EXPERIMENTS ON THE INFLUENCE OF EXTERNAL FACTORS ON THE DEVELOPMENT OF PROTODERMAL OUTGROWTHS

In the autumn of 1914, suckers from the roots of three plants (No. 7-2, *R. allegheniensis* × *frondosus*, No. 4-1, *R. allegheniensis* Porter and No. 8-2, *R. baileyanus* Britton) were transplanted into large-sized pots containing soil which previously had been made thoroughly uniform by mixing. These were left out of doors until December 1, when they were transferred to four different plots in three different greenhouses. Here they were kept under controlled conditions until April 12, when the experiment was discontinued. All stem growth, therefore, was made during the interval between De-

cember 1 and April 12. By the use of three sets of Friez self-recording instruments continuous records were kept of humidity, soil temperature and air temperature during this period for each individual house. Light readings were also taken in the different plots at various intervals of time. Table I gives the average weekly humidity, soil temperature and air temperature of these different plots as well as the total average for the entire period. These weekly averages were computed by using the recorded percentage humidity and degrees temperature at intervals of two hours for the entire week. Of course it must be admitted that averages are often misleading. Since, however, the conditions recorded showed no abrupt variations this method of tabulation was thought sufficiently accurate.

TABLE I. TEMPERATURE, HUMIDITY AND LIGHT CONDITIONS FOR THE DIFFERENT PLOTS

Greenhouse	I			II			III		
	Plot I. Full sunlight			Plot II. Full sunlight			Plot III. and IV. Indirect light		
Week ending	Humidity	Soil temperature	Air temperature	Humidity	Soil temperature	Air temperature	Humidity	Soil temperature	Air temperature
	%	°F	°F	%	°F	°F	%	°F	°F
Dec. 7	67	61	69	59	56	60	68.5	68	68
Dec. 14	56.5	62	70	50.5	56	61	65.5	64	67.5
Dec. 21	56.5	60.5	68	47.5	50	56	57.5	60.5	68
Dec. 28	54	58	65	45	50	56	58	59.5	65
Jan. 4	55	60.5	68	50	51	57	62	63	67
Jan. 11	60	61	68.5	52	53.5	60.5	61.5	66	70.5
Jan. 18	58.5	62	70	47	52.5	60.25	62.5	65	69
Jan. 25	59	60	67	51	51.5	60	63	65	69.5
Feb. 1	57	60	66	50.5	50	57	63.5	62	67
Feb. 8	58.5	60	66.5	50	51.5	61	65	64	70
Feb. 15	57	61	68	52	51.5	59.5	62	65	69.5
Feb. 22	69.5	58	67	55	51.5	60	63	67	73
Mar. 1	77.5	57.5	67	60	51	60.5	68	66.5	71.5
Mar. 8	73	57.5	66	58	50.5	60	66	64	67.5
Mar. 15	80	58	64	59	50	59.5	64	64	68.5
Mar. 22	77.5	59	65	59	50.5	60	70	64	69.5
Mar. 29	77.5	60	64.5	61.5	51	60	69	68	70
Apr. 5	77	58.5	64	60	48	58	71.5	68	71.5
Apr. 12	80	59.5	67	63	52.5	65	69	66	68
Average of the weekly averages	65.84	59.68	66.86	54.21	51.50	59.53	64.71	64.71	68.97

Plants in plots I and II grew in full sunlight under ordinary greenhouse conditions; plants in plot III grew under three layers of cheesecloth, reducing the light value to approximately one-fourth

that of plots I and II; while plants in plot IV grew in the same greenhouse as those in plot III but the light value for this plot was approximately three-fifths of that for plots I and II.

At the conclusion of this experiment data were taken on several plants from each of the four plots including the number and development of the glandular hairs and prickles on the stem, petioles and leaflets as well as the leaf area and other characters not tabulated here. Tables II and III (p. 10) give a summary for ten plants grown from the shoots of *R. allegheniensis* × *frondosus* (No. 7-2). This plant was selected because the prickles and glandular hairs as well as the simple hairs are very conspicuous. The plants of *R. allegheniensis* Porter showed similar variations in the number of glandular hairs and prickles. Plate II shows a portion of the stem of a shoot of *R. allegheniensis* × *frondosus* grown in plot III, while plate III shows a corresponding section of a similar plant grown in plot I.

TABLE II. NUMBER OF PROTODERMAL OUTGROWTHS ON PLANTS GROWN IN THE DIFFERENT PLOTS

			Glandular hairs ·			Prickles		
	Length of stem in cm.	No. of leaves on stem	On leaflets	On petioles	On stem	On leaflets	On petioles	On stem
Plot I.								
Plant 1	50	13	1090	988	850	1173	433	165
Plant 2	74	15	1886	1950	2442	1050	407	185
Plot II.								
Plant 1	41	12	2517	3581	1465	1393	603	147
Plant 4	52	13	2007	1755	884	1268	619	130
Plot III.								
Plant 1	118	14	49	24	7	980	305	158
Plant 2	158	18	54	2	0	1386	344	201
Plant 3	145	16	154	36	46	1077	352	190
Plant 4	168	25	192	46	2	1060	385	212
Plot IV.								
Plant 1	43	9	242	83	105	736	254	123
Plant 2	49	14	436	287	124	996	312	146

Since *R. baileyanus* Britton is almost devoid of conspicuous glandular hairs, these plants showed little or no variation in this character, while shoots of this parentage grown in plots I and II showed an increased growth in the number and size of the prickles as compared with those grown in the other plots.

These experiments were repeated during 1915-16, using the same roots but placing them in different plots. Other species, including

R. groutianus Blanchard and *R. frondisentis* Blanchard, were also used. Similar results were obtained for each plot as those of the preceding year.

Hereditary differences were overcome in these experiments by using shoots from the same plant for comparison; and since the soil was uniform for all plots and the water content kept as uniform as possible throughout the growing period, the only principal factors that would vary for the different plots were humidity, temperature and light. Consequently, any variation in the growth of these plants must be in a measure a response on the part of the plant to one or more of

TABLE III. SUMMARY OF THE TOTAL NUMBER OF GLANDULAR HAIRS AND PRICKLES AND TOTAL LEAF AREA FOR PLANTS IN THE DIFFERENT PLOTS

	Glandular hairs	Prickles	Leaf area in sq. cm.
Plot I.			
Plant 1	2928	2143	2156.47
Plant 2	6278	1642	2717.40
Plot II.			
Plant 1	7563	2143	2156.47
Plant 4	4646	2017	2108.81
Plot III.			
Plant 1	80	1443	2997.12
Plant 2	56	1931	4261.58
Plant 3	236	1619	3863.41
Plant 4	240	1657	2572.65
Plot IV.			
Plant 1	430	1113	1500.63
Plant 2	847	1450	2784.02

these varying factors. By referring to table III a great variation in the number of glandular hairs and prickles will be noted. This variation becomes more apparent if we use for a standard of comparison

$$\frac{\text{total number of glandular hairs}}{\text{total leaf area in sq. cm.}} \quad \text{and} \quad \frac{\text{total number of prickles}}{\text{total leaf area in sq. cm.}}$$

Table IV gives a summary of these values and the varying factors for each plot. A study of this table will show that temperature is not to any material extent a determining factor in the formation of glandular hairs and prickles. Plants grown in plots I and III with a comparatively small difference in temperature show a large differ-

ence in the development of glandular hairs and prickles (plates II and III). Humidity, which has been considered a very important factor in the formation of spines and spinescent emergencies, does not seem to affect their development as greatly as might be expected. In plots where the average humidity was about the same, the plants showed a wide variation in the production of glandular hairs and prickles; and in like manner for plots III and IV. The only remaining variable, namely, light, must, therefore, be the main determining factor. And it will be noted that the number of these outgrowths on the different plants for each plot is almost in direct proportion to the intensity of the light. This is partly in agreement with the work of Lothelier and others (3, 4, 5). A corresponding variation in the abundance of simple hairs also occurred but is not tabulated here.

It was thought that irritation, such as a plant growing in a windy

TABLE IV. A COMPARISON OF THE NUMBER OF PROTODERMAL OUTGROWTHS AND THE CONDITIONS UNDER WHICH THE PLANT WAS GROWN

	Average humidity	Average soil temperature	Average air temperature	Comparative light values	Total number of prickles / Total leaf area sq. cm.	Total number of glandular hairs / Total leaf area sq. cm.
Plot I.	%	°F	°F			
Plant 1					92	153
Plant 2					60	231
Average	65.84	59.68	66.86	1	76	192
Plot II.						
Plant 1					99	350
Plant 4					95	220
Average	54.21	51.50	59.53	1	97	285
Plot III.						
Plant 1					48	2
Plant 2					45	1
Plant 3					41	6
Plant 4					64	9
Average	64.71	64.71	68.97	.25	49.5	4.5
Plot IV.						
Plant 1					74	28
Plant 2					52	30
Average	64.71	64.71	68.97	.6	63	29

station would be subjected to, might be a factor in the production of protodermal outgrowths. To test this supposition, shoots were tied to a lever which was attached to a water-motor in such a manner as to give the plant a swaying motion, imitating the motion of a shoot blown to and fro in the wind. This treatment, however, had no apparent effect upon the development of hairs or prickles.

The taxonomic value of simple hairs, glandular hairs and prickles in this genus is not questioned; yet it is evident from the preceding data that only by comparative study of plants grown under essentially similar conditions can these structures furnish a reliable criterion for classification.

MORPHOLOGY OF THE PROTODERMAL OUTGROWTHS

The prickle, glandular hair, and simple hair are all protodermal or epidermal outgrowths, and the primordia of all three structures are present in all New England species of blackberries. The glandular hairs and prickles are especially conspicuous in all seedlings (plate IV, fig. 7). They may remain rudimentary as is the case of the glandular hairs on the same species (plate IV, fig. 4) and thus their presence may not be noted in the mature plants.

The simple hairs are unicellular structures (plate IV, fig. 2). These develop from certain cells from the outer layer of the protoderm which at first become conspicuous by the enlargement of their nuclei (plate IV, fig. 1) and, later, by a tangential elongation.

The glandular hairs, as well as the prickles, have a similar origin. The cell primordia of these structures, however, do not show an enlargement of their nuclei, but at an early stage undergo a tangential division (plate IV, fig. 3). These cells may then divide both periclinally and anticlinally (plate IV, fig. 6) resulting in the formation of a glandular hair or prickle. In some instances, two or more protodermal cells may enter into the formation of these structures (plate IV, fig. 5), but this does not in any way alter their development. There is no morphological difference between the glandular hair and the prickle except that in the former the terminal cells change into large, secretive organs. The prickle is often, though not always, a development from the glandular hair (plate V, fig. 1), so that every glandular hair is a potential prickle.

VARIABILITY AND ITS RELATION TO HYBRIDIZATION

Unusual variability in plants and animals is generally regarded by students of genetics as almost conclusive evidence of hybridity of origin. The practical breeder has long recognized this fact. The main purpose of artificial hybridization is to "break up the continuity of the germ plasm" (6), thus bringing about greater plasticity in the individual plants or animals of the resulting progeny.

If plasticity in the individual is a mark of hybridity of origin, the variations which occur in the growth of the blackberries as shown in the preceding data is a striking evidence of the hybrid origin of the blackberries.

STERILITY AND ITS RELATION TO INTERBREEDING

Absolute or partial sterility has long been recognized as a mark of hybridity of origin. Gärtner (7), as early as 1849, pointed out this peculiarity in hybrids. It is so common a character among plants of hybrid origin and it is so universally recognized as the result of interbreeding that little need be said concerning this phenomenon at this point. One need but refer to the various articles dealing with the productivity of our common cultivated fruits, which are largely of hybrid origin, to find convincing data in support of this general assertion (8, 9). There are, to be sure, apparent isolated instances of perfectly fertile hybrids, as shown by Rosen (10) and others. An interesting example of this occurred in our cultures. In 1914, No. 12-3, *R. vermontanus* Blanchard was crossed with No. 14-5, *R. jacens* Blanchard. Both parent plants produced pollen which was only about 15 percent morphologically perfect (plate VIII, fig. 1 and plate XI, fig. 1). The resulting plants from this cross, however, produced about 90 percent morphologically perfect grains (plate XI, fig. 2). The percentage of fertile ovules was also very much greater in the offspring than in either of the parent plants. Such cases, however, are but exceptions and not the rule and it may possibly be shown later, when our conception of hybrids becomes more definite, that even these may not be exceptions.

Some of our prominent students of genetics contend that absolute fertility in the offspring is a convincing proof that the parents are specifically alike. Bateson (11), as expressed in his very able work, believes that "complete fertility of the results of interbreeding is and must be regarded as inconsistent with actual specific difference." This,

however, must not be interpreted to mean that sterility in a certain plant, no matter what may have been its cause, is an absolute proof of its hybridity.

Jeffrey (12, 13, 6, 14), and his students (15, 16), in several quite recently published articles on plant morphology as bearing on evolution, hold the view that a certain type of sterility, *i. e.*, aborted pollen, in a certain species is in itself sufficient proof of its hybridity. His conclusions are, however, based upon quite crude though extensive investigations of this phenomenon and may thus be subjected to serious criticism.

In view of this attributed correlation between hybridity of origin and sterility, the following studies were undertaken with the expectation that they might throw some light on the important subject of interbreeding as it occurs in this group and that they might also furnish some data in regard to the origin of some of the many doubtful species of Rubus. All the material used for this work was obtained either from carefully labeled plants growing in the wild which, afterwards, were transplanted to the Vermont Station gardens, or from plants similarly obtained which had been transferred to the gardens during the preceding year. This procedure would seem to eliminate, so far as was humanly possible, any error in naming the plants, since they were verified not only as they grew in the wild, but also as they grew under cultivation where they could be studied during the entire season. It may be argued that by transplanting the plants and placing them under cultivated conditions the spore formation powers of these plants might be materially affected. This, however, we have not found to be the case.

It must be remembered that sterility may result from various causes. It may be due to purely external factors, such as injury to the pistils or stamens by frosts, insects, etc. (17). It may result from a lack of proper pollination, that is to say, pollination may take place too late, too early, or not at all. Such types of infertility, however, have very little significance as evolutionary factors although they may be vitally important to the practical horticulturist. On the other hand, infertility may be due to defects in the formation of the microspore or megaspore and their resulting gametophytes, or it may be due to the lack of functional power in the male or female elements. These last mentioned types of infertility are fundamental variations in respect to the perpetuation of any particular species. They are, therefore, important in a consideration of this group.

METHODS USED IN STUDYING INFERTILITY IN PLANTS

Infertility, especially among cultivated plants, has been quite extensively investigated. Probably the oldest method (18) and one that is in common use at the present time, is that of bagging the flowers. A bag of paper or other material is placed over the unopened flower and permitted to remain until the fruit has "set." By this method quite reliable data can be obtained in regard to self-fertility, although if relied upon exclusively it may be subject to serious criticism, as will be shown later.

Since cytological technique has come into common usage several workers, especially Dorsey (19) and Lutz (20), have used this method in studying sterility and by its use valuable data concerning this phenomenon have been obtained. It has been shown by this method that sterility among flowering plants in the majority of cases is due to the degeneracy of the microspores. Degeneracy in the pistil is quite rare. This has led to a careful study of the formation and development of the microspore. In some instances the percentage of aborted pollen has been used as an index of sterility (15, 6) while in others the capability of microspore germination in some artificial media has been likewise used (17, 22, 23).

Aside from these methods, a comparative study of the results of cross- and close-pollination has added greatly to our knowledge of sterility in plants.

SELF-STERILITY OF RUBUS AS SHOWN BY BAGGING

For this work only plants growing in the gardens were used. In this way it would seem that more accurate data concerning the comparative infertility of the different so-called species could be obtained than if the same work had been done in the field where the plants inevitably would be growing under quite different conditions. Parchment bags were used. These were placed over the flowers one or two days before the flowers opened and left until the fruit had "set." Only fully developed seeds were counted.

It has been noted among other groups of the flowering plants that fertilization occurs more readily when the pollen from the flower on a different part of the same plant is used for pollination than if the pollen from the same flower is used. In the clovers Westgate (24) finds this difference to be very great. This does not seem to be the case in the Rubus studied. Quite extensive comparisons in this re-

spect were made with a number of plants including the following species: *R. allegheniensis* Porter, *R. frondosus* Bigelow, *R. canadensis* L. and *R. setosus* Bigelow. Little or no difference in the number of seeds formed per flower were noted. For the sake of uniformity, however, only four or five flowers were enclosed in each bag.

Table V gives a detailed list of the plants used in this work together with the number of flowers bagged and those not bagged on each plant and table VI summarizes the data.

TABLE V. SHOWING RESULTS OF CLOSE AND INSECT POLLINATION

No.	Plant name	Bagged		Not bagged	
		Number of flowers	Number of seed formed	Number of flowers	Number of seed formed
4-1	*R. allegheniensis* Porter	48	0	36	1260
202-1	*R. allegheniensis* Porter	23	0	45	1832
125-1	*R. allegheniensis* Porter	141	0	84	2940
212-1	*R. allegheniensis* Porter	7	0	203	5175
120-1	*R. allegheniensis* × *argutus* (andrewsianus Blanchard)	8	15	16	192
120-3	*R. allegheniensis* × *argutus* (andrewsianus Blanchard)	14	26	8	95
13-4	*R. allegheniensis* × *canadensis*	7	16	32	835
310-1	*R. allegheniensis* × *canadensis*	8	16	30	793
13-1	*R. allegheniensis* × *canadensis*	16	20	122	310
13-3	*R. allegheniensis* × *canadensis*	126	182	4	28
13-4	*R. allegheniensis* × *canadensis*	136	109	1	9
13-6	*R. allegheniensis* × *canadensis*	330	340	8	43
46-1	*R. allegheniensis* × *elegantulus* (R. flavinanus Blanchard)	48	93	41	615
46-2	*R. allegheniensis* × *elegantulus* (R. flavinanus Blanchard)	15	36	63	1003
7-2	*R. allegheniensis* × *frondosus*	149	6	506	3669
204-1	*R. allegheniensis* × *hispidus* (R. permixtus Blanchard)	13	0	17	183
205-1	*R. allegheniensis* × *hispidus* (R. permixtus Blanchard)	13	14	82	8341
213-1	*R. baileyanus* Britton	28	6	47	612
8-1	*R. baileyanus* Britton	5	1	11	163
216-1	*R. baileyanus* Britton	16	19	28	291
13-2	*R. canadensis* L.	80	80	68	1714
13-5	*R. canadensis* L.	42	37	14	368
133-1	*R. canadensis* × *setosus* (R. junceus Blanchard)	16	21	14	11
105-1	*R. elegantulus* × *setosus* (R. groutianus Blanchard)	12	0	15	129
105-2	*R. elegantulus* × *setosus* (R. groutianus Blanchard)	12	2	31	235
105-3	*R. elegantulus* × *setosus* (R. groutianus Blanchard)	14	2	7	27
105-8	*R. elegantulus* × *setosus* (R. groutianus Blanchard)	9	0	33	429
31-1	*R. elegantulus* × *setosus* (R. groutianus Blanchard)	6	1	7	28

111-1	*R. flagellaris* × *setosus* (R. tardatus Blanchard)	16	17	23	59
7-3	*R. frondosus* Bigelow	62	211	25	513
17-1	*R. frondosus* Bigelow	11	31	62	591
17-2	*R. frondosus* Bigelow	7	24	11	96
17-3	*R. frondosus* Bigelow	10	17	26	248
17-4	*R. frondosus* Bigelow	14	60	24	254
17-5	*R. frondosus* Bigelow	12	21	114	657
121-3	*R. frondosus* Bigelow (R. brainerdi Rydb.)	10	12	15	129
137-1	*R. frondosus* × *setosus* (R. abbrevians Blanchard)	18	42	6	138
137-3	*R. frondosus* × *setosus* (R. abbrevians Blanchard)	62	155	18	396
38-1	*R. hispidus* L.	9	0	12	1
203-1	*R. hispidus* L.	9	0	44	457
209-1	*R. hispidus* L.	14	34	106	1021
14-1	*R. hispidus* × *setosus* (R. jacens Blanchard)	23	0	400	96
14-2	*R. hispidus* × *setosus* (R. jacens Blanchard)	4	1	260	16
14-3	*R. hispidus* × *setosus* (R. jacens Blanchard)	31	1	12	2
14-4	*R. hispidus* × *setosus* (R. jacens Blanchard)	8	0	234	14
14-5	*R. hispidus* × *setosus* (R. jacens Blanchard)	16	1	781	29
14-6	*R. hispidus* × *setosus* (R. jacens Blanchard)	130	8	594	77
101-3	*R. hispidus* × *setosus* (R. jacens Blanchard)	10	1	18	132
1-1	*R. hispidus* × *setosus* (R. trifrons Blanchard)	24	2	417	1547
117-1	*R. hispidus* × *setosus* (R. trifrons Blanchard)	120	7	262	833
117-2	*R. hispidus* × *setosus* (R. trifrons Blanchard)	40	3	42	304
32-1	*R. hispidus* × *setosus* (R. trifrons Blanchard)	7	0	3	33
48-2	*R. pergratus* Blanchard	48	13	44	794
48-3	*R. pergratus* Blanchard	112	34	36	643
119-6	*R. setosus* Bigelow	42	116	20	64
119-2	*R. setosus* Bigelow	26	83	85	578
12-1	*R. vermontanus* Blanchard	82	52	1056	6135
12-2	*R. vermontanus* Blanchard	51	2	419	568

One must not rely too much upon the data set forth in these tables. Any attempt to correlate these figures with the amount of sterility in a given species would be highly unscientific. It is obvious that when the flowers are bagged fertilization must take place under very much more unfavorable conditions than under normal conditions. Not only are the temperature, humidity and light factors greatly changed, and it has been shown by Sandsten (17) that these affect the development of the microspore materially, but it might also be argued that the chances for proper pollination were greatly reduced by enclosing the flowers in bags. It was shown, however, that the shaking of the bags by the wind effectively pollinated the flower. And since

TABLE VI. SUMMARY OF DATA GIVEN IN TABLE V.

Name	Average number of seed formed per flower when bagged	Average number of seed formed per flower when not bagged
R. alleghenicnsis Porter	0.00	30.45
R. andrewsianus Blanchard	1.86	11.95
R. orarius Blanchard	1.09	10.24
R. flavinanus Blanchard	2.04	15.55
R. alleghenicnsis × *frondosus*	.04	7.25
R. permixtus Blanchard	.53	86.10
R. baileyanus Britton	.53	12.39
R. canadensis L.	.95	25.39
R. junceus Blanchard	1.31	.78
R. groutianus Blanchard	.09	9.11
R. tardatus Blanchard	1.06	2.56
R. frondosus Bigelow	3.13	9.00
R. brainerdi Rydb.	1.20	8.60
R. abbrevians Blanchard	2.46	22.25
R. hispidus L.	1.06	9.12
R. jacens Blanchard	.05	.15
R. trifrons Blanchard	.06	3.75
R. pergratus Blanchard	.29	17.96
R. setosus Bigelow	2.92	6.11
R. vermontanus Blanchard	.40	4.54

only the comparative sterility of the different species was sought, these and other factors would not materially affect the value of the data.

Another factor which would make the data obtained by this method valueless is the quite uncommon phenomenon of apogamy. This, however, does not occur in the Rubus studied or it would have become apparent both in the latter cytological studies as well as in the checks used in connection with the cross-pollination work (table XII, p. 27).

From a study of tables V and VI three facts become very apparent. These are also corroborated by the results obtained by other methods which will be referred to later.

1. A large percentage of infertility occurs in most of the blackberries. The amount of infertility, as shown in table VI in the case of the flowers not bagged, ranges from an average of only 86.10 fertile ovules per flower in *R. permixtus* Blanchard to almost complete sterility in the case of *R. jacens* Blanchard. It will also be noted that in general the greatest percentage of sterility is found among well-recognized hybrids as *R. alleghenicnsis* × *frondosus*, *R. junceus* Blanchard, *R. trifrons* Blanchard and *R. jacens* Blanchard. Those showing least infertility are the distinct and universally recognized species, like *R. alleghenicnses* Porter, *R. canadensis* L., and *R. baileyanus* Britton.

PLATE I.

Rubus frondosus Bigelow, 17-5, showing response to light. The erect cane at the center (which is the old cane) grew in the shade, while the trailing stems grew the following season in no shade.

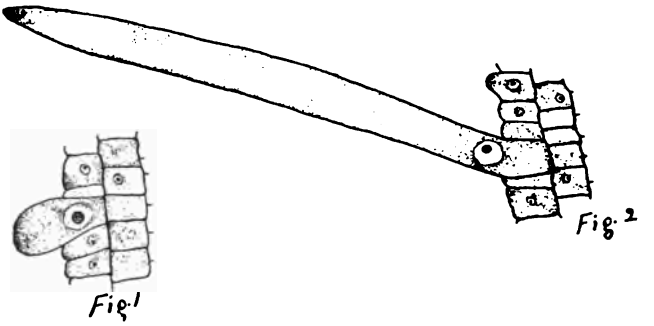
PLATE II.

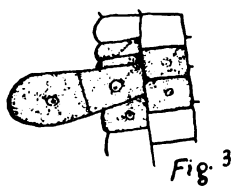
Rubus allegheniensis × *frondosus*. Natural size. Tip of a sucker from plant 7-2, which grew in plot III under three layers of cheesecloth. Note the weak prickles and the absence of simple hairs and gland-tipped hairs.

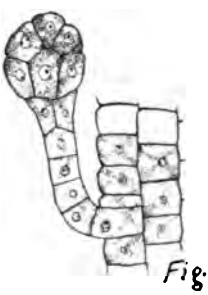
PLATE III.

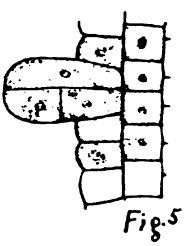
Rubus allegheniensis × *frondosus*. Natural size. Tip of a sucker from plant 7-2, which grew in plot II in full sunlight. Note the abundance of simple hairs, gland-tipped hairs and prickles.

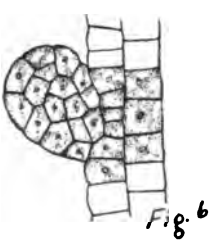
PLATE IV.











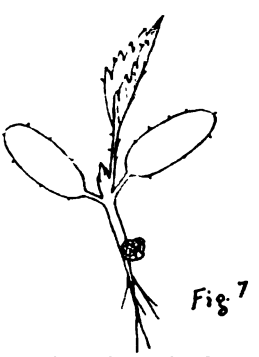


Figure 1. *Rubus allegheniensis* Porter. A section through the outer portion of growing tip showing the enlarged protodermal cell, which may later develop into a simple hair as shown in figure 2. X 665.

Figure 2. *Rubus allegheniensis* Porter. Showing the enlarged cell of the protoderm developed into a simple hair. X 665.

Figure 3. *Rubus allegheniensis* Porter. Showing a tangential division of a protodermal cell which may later develop into either a prickle or a glandular hair. X 665.

Figure 4. *Rubus canadensis* L. Showing an aborted glandular hair. These are present on all blackberries. X 665.

Figure 5. *Rubus allegheniensis* × *frondosus*. Showing two protodermal cells entering into the formation of a glandular hair or prickle, one having already divided while the other has not. X 665.

Figure 6. *Rubus allegheniensis* Porter. Showing the result of the rapid periclinal and anticlinal divisions of the protodermal cell which will later develop into a conspicuous glandular hair or prickle as shown in plate V, fig. 1. X 665.

Figure 7. *Rubus canadensis* L. Showing glandular hairs and prickles on seedling. X 2.

PLATE V.

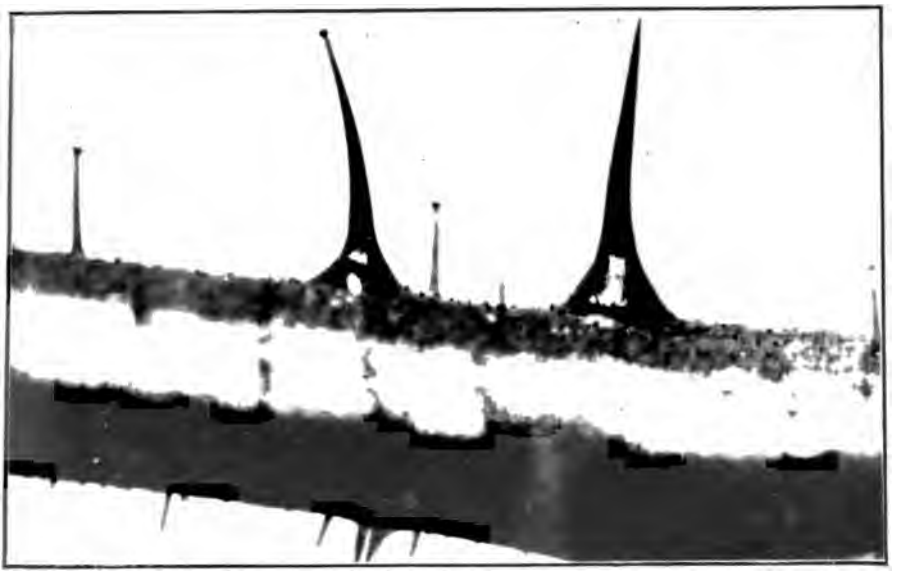


Figure 1. *Rubus alleghenienſis* Porter showing the numerous aborted gland-tipped hairs, the normally developed gland-tipped hairs, the gland-tipped hair developed into a prickle with the gland still remaining at the tip (at center) and a normally developed prickle. Photographed and enlarged six diameters.

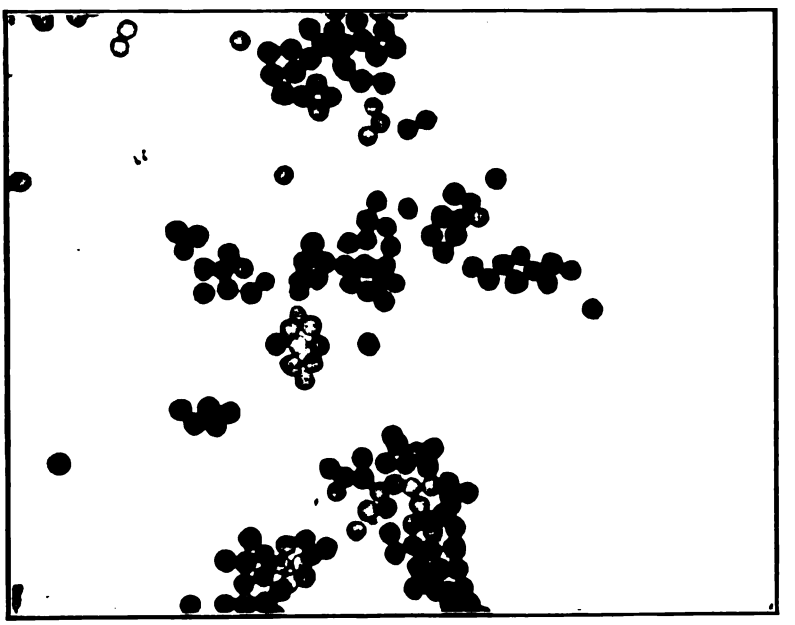


Figure 2. Micro-photograph of pollen grains of *Rubus alleghenienſis* Porter, 125-1, a pubescent form. X 85.

PLATE VI.

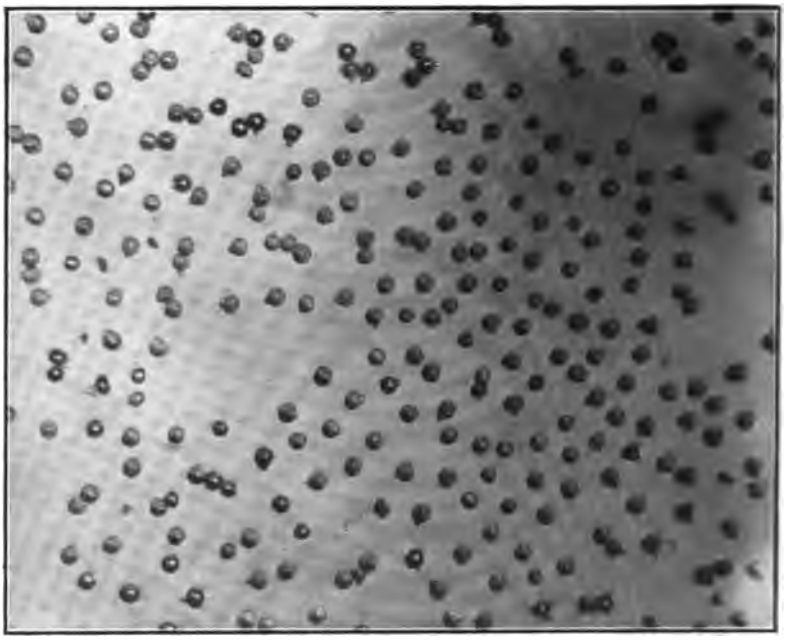


Figure 1. Micro-photograph of pollen grains of *Rubus alleghenienses* Porter, 4-1. X 85.

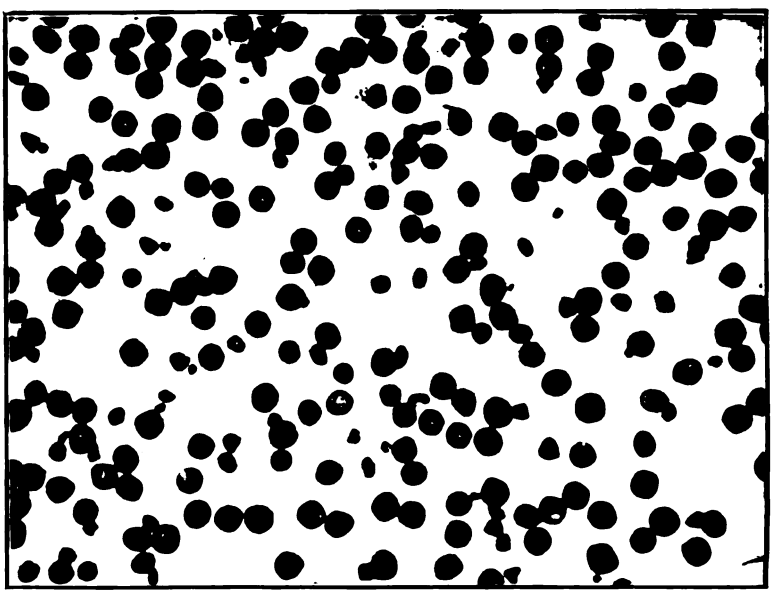


Figure 2. Micro-photograph of pollen grains of *Rubus pergratus* Blanchard, 48-3. X 85.

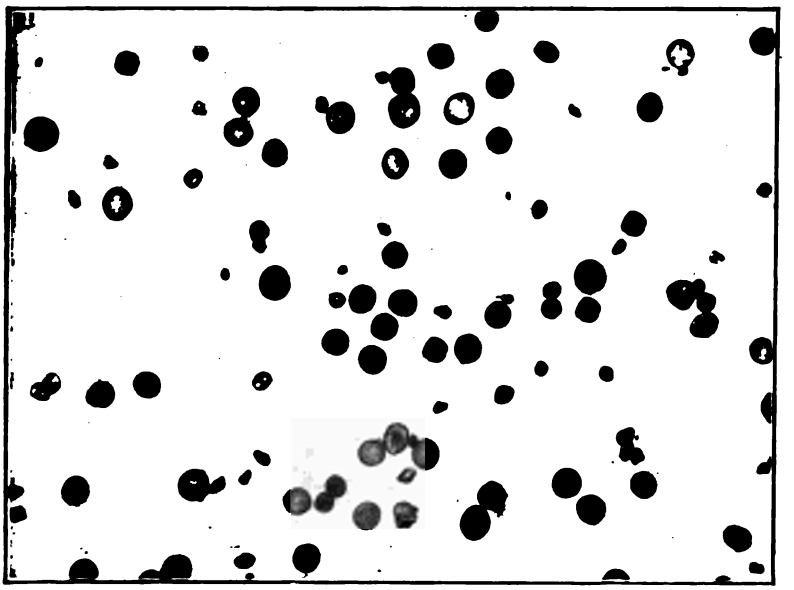


Figure 1. Micro-photograph of pollen grains of *Rubus frondosus* Bigelow, 17-4. X 85.

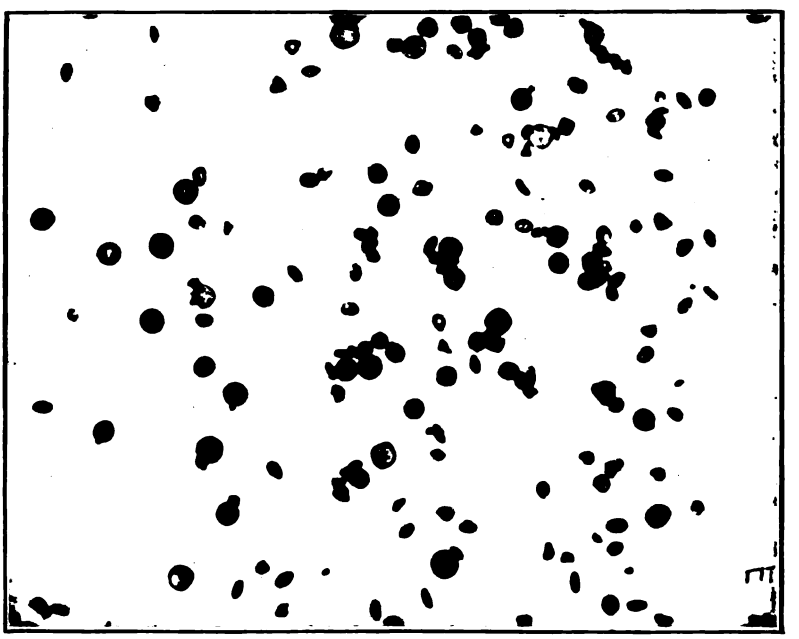


Figure 2. Micro-photograph of pollen grains of *Rubus canadensis* L., 13-5. X 85.

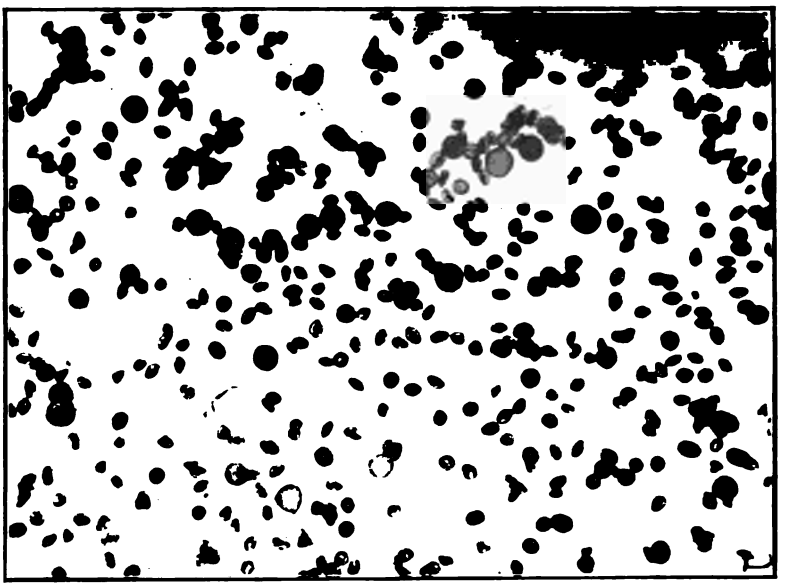


Figure 1. Micro-photograph of pollen grains of *Rubus vermontanus* Blanchard, 12-3. X 85.

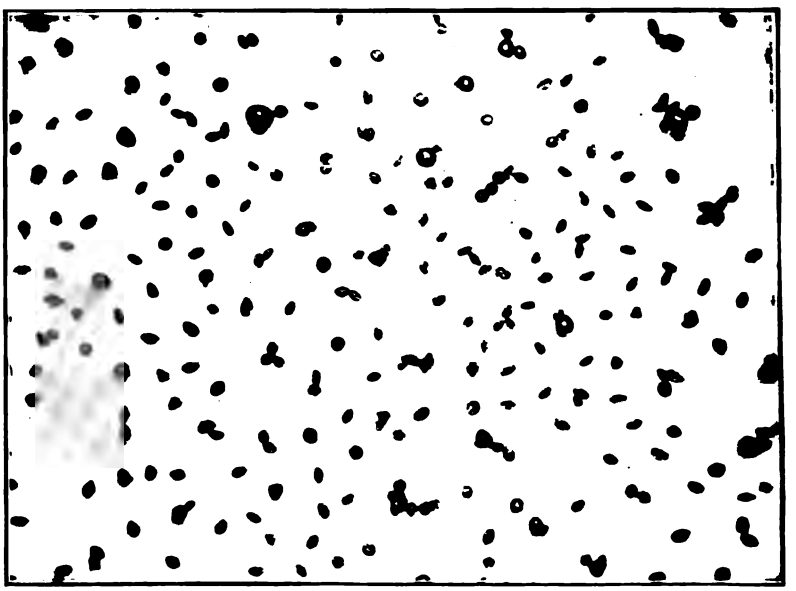


Figure 2. Micro-photograph of pollen grains of *Rubus hispidus* L., 203-1. X 85.

PLATE IX.

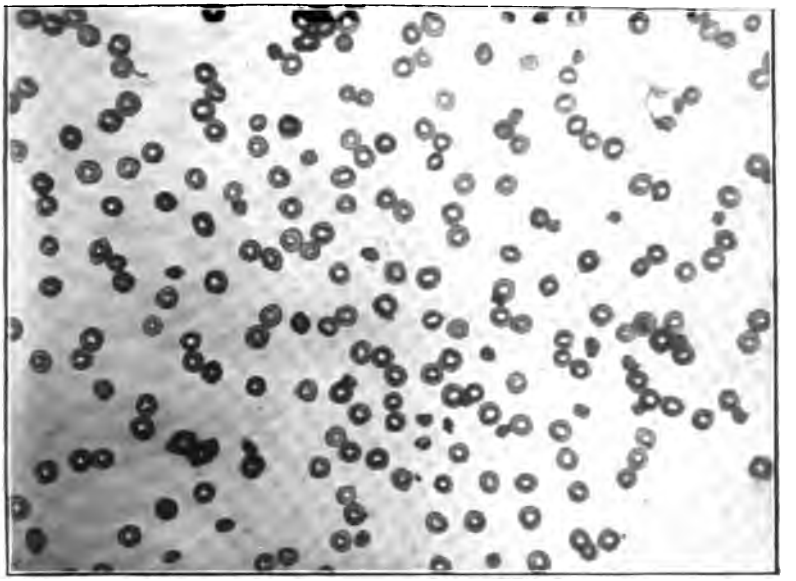


Figure 1. Micro-photograph of pollen grains of *Rubus baileyanus* Britton, 216-1. X 85.

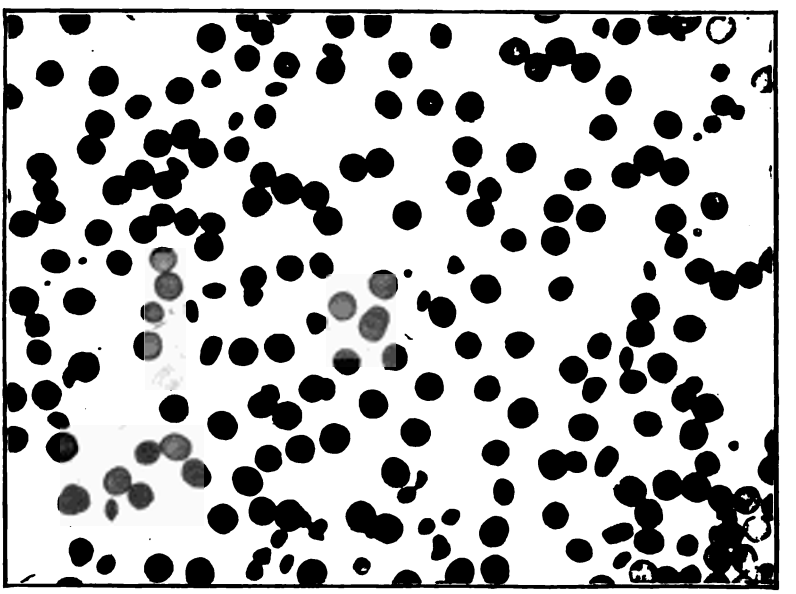


Figure 2. Micro-photograph of pollen grains of *Rubus flagellaris* Willd., 252-2. X 85.

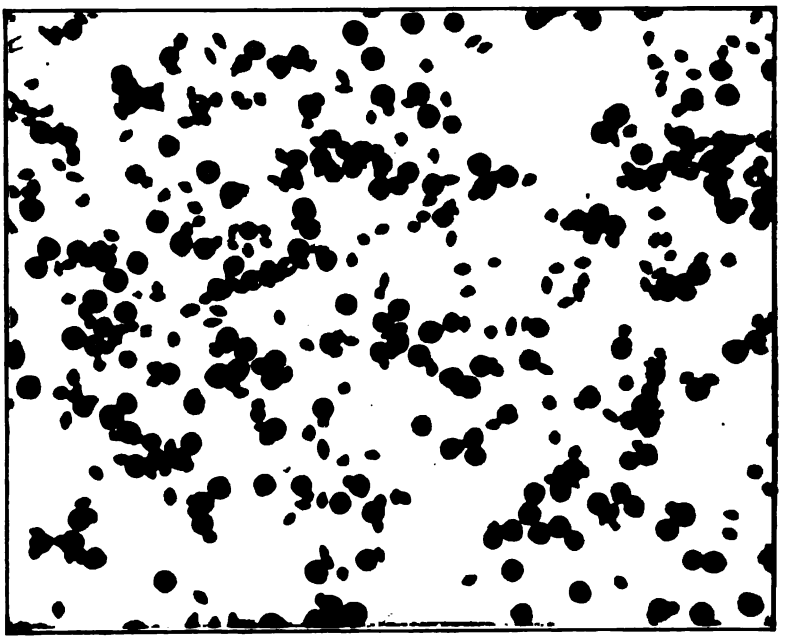


Figure 1. Micro-photograph of pollen grains of *Rubus alleghenienses* × *canadensis*, 13-1 (*Rubus orarius* Blanchard). X 85.

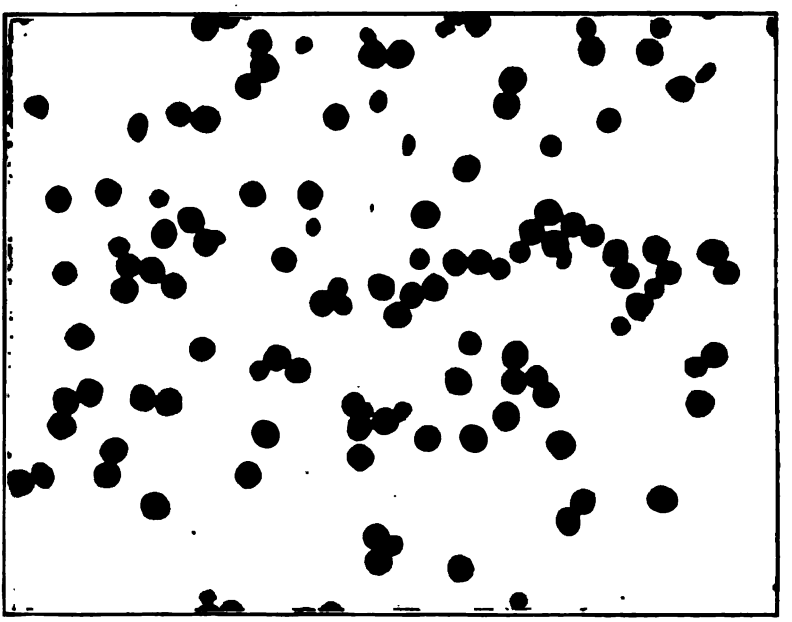


Figure 2. Micro-photograph of pollen grains of *Rubus baileyanus* × *flagellaris*, 252-4 (*Rubus invisus* [Bailey] Britton). X 85.

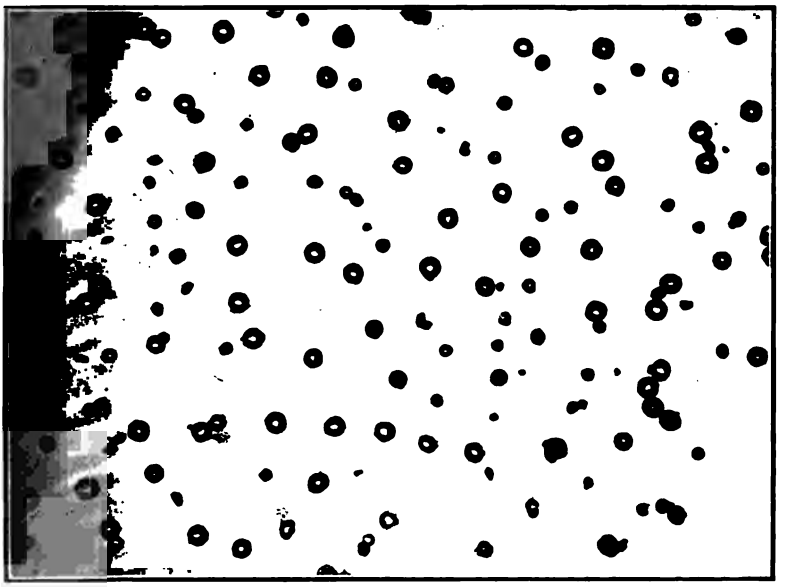


Figure 1. Micro-photograph of pollen grains of *Rubus hispidus* × *setosus*, 14-5 (*Rubus jacens* Blanchard). X 85.

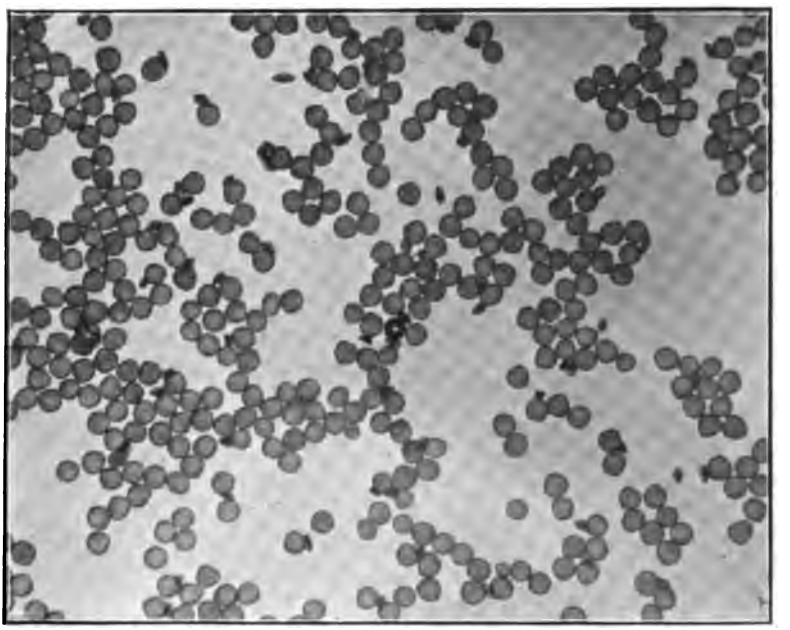


Figure 2. Micro-photograph of pollen grains of plant number 1005-4, which is a seedling whose maternal parent is *Rubus vermontanus* Blanchard, 12-3, and whose paternal parent is *Rubus jacens* Blanchard, 14-5. X. 85. Note the large percentage of morphologically perfect pollen. Compare with plate VIII, fig. 1, and plate XI, fig. 1, which shows the pollen of its two parents.

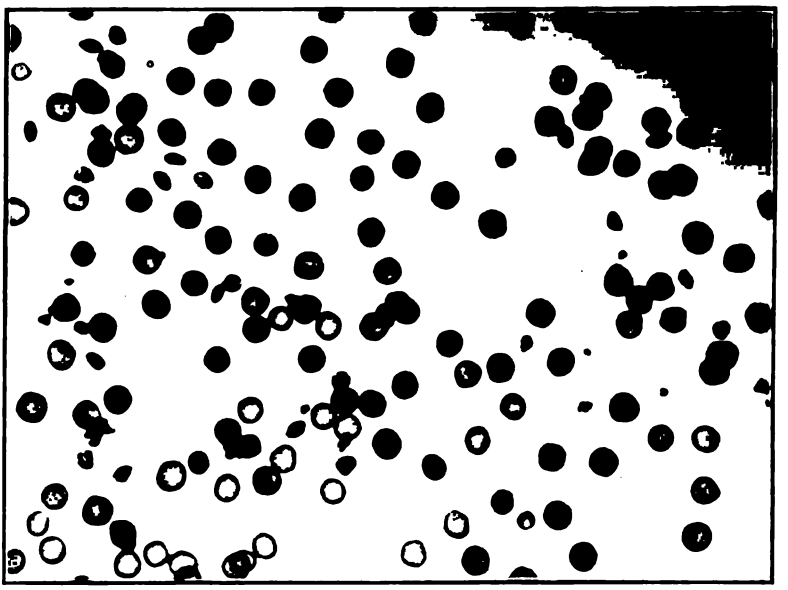


Figure 1. Micro-photograph of pollen grains of *Rubus pergratus* × *setosus*, 136-2 (*Rubus frondisentis* Blanchard). X 85.

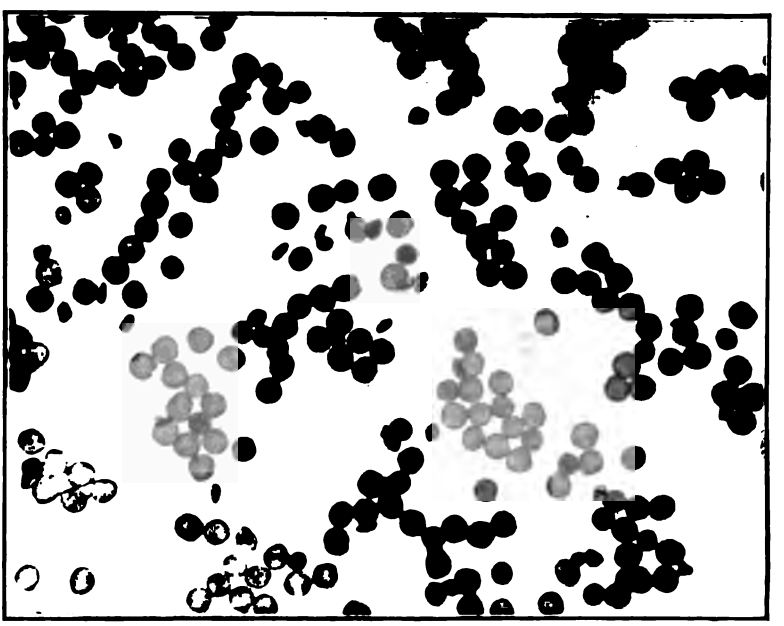


Figure 2. Micro-photograph of pollen grains of *Rubus frondosus setosus*. 137-1 (*Rubus abbrevians* Blanchard). X 85.

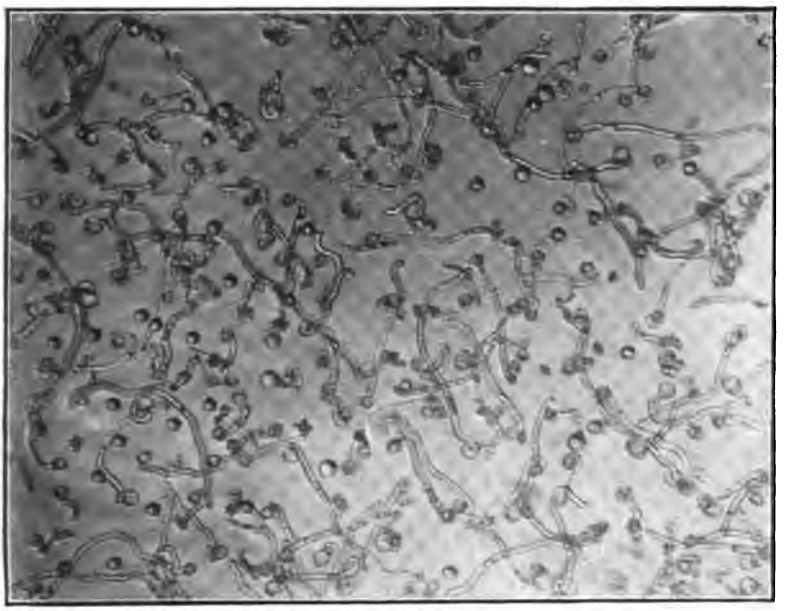


Figure 1. Micro-photograph of pollen grains of *Rubus alleghenienses* Porter, 4-1. Germinated in a hanging drop culture of 12 percent cane sugar solution for three hours. X 85.

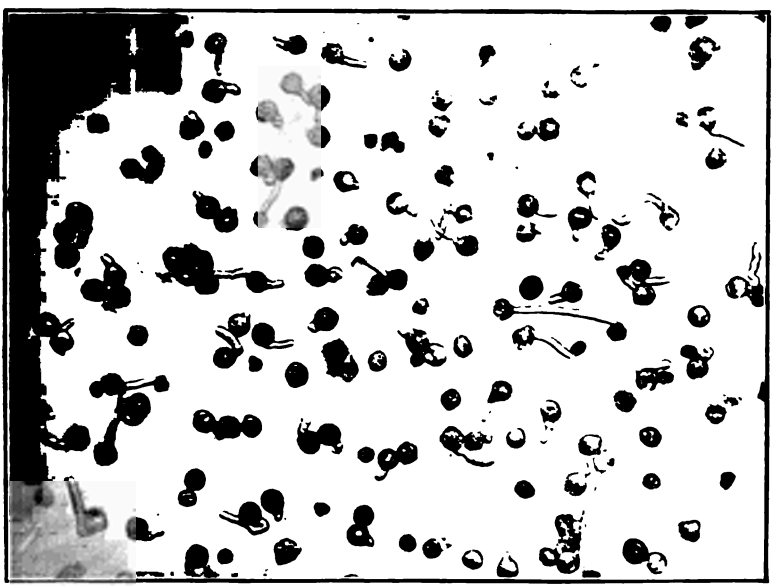


Figure 2. Micro-photograph of pollen grains of *Rubus baileyanus* Britton, 216-1. Germinated in a hanging drop culture of 12 percent cane sugar solution for one hour. X 85.

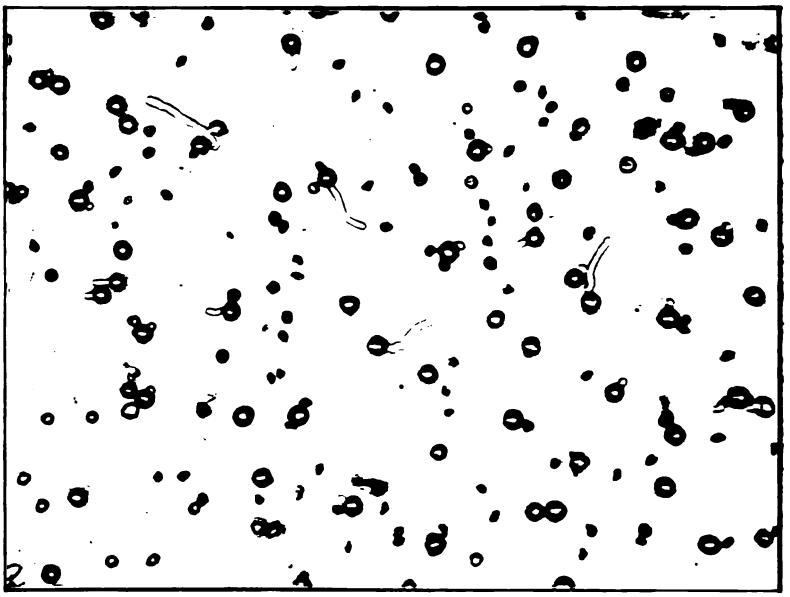


Figure 1. Micro-photograph of pollen grains of *Rubus frondosus* Bigelow, 17-4. Germinated in a hanging drop culture of 12 percent cane sugar solution for four hours. X 85.

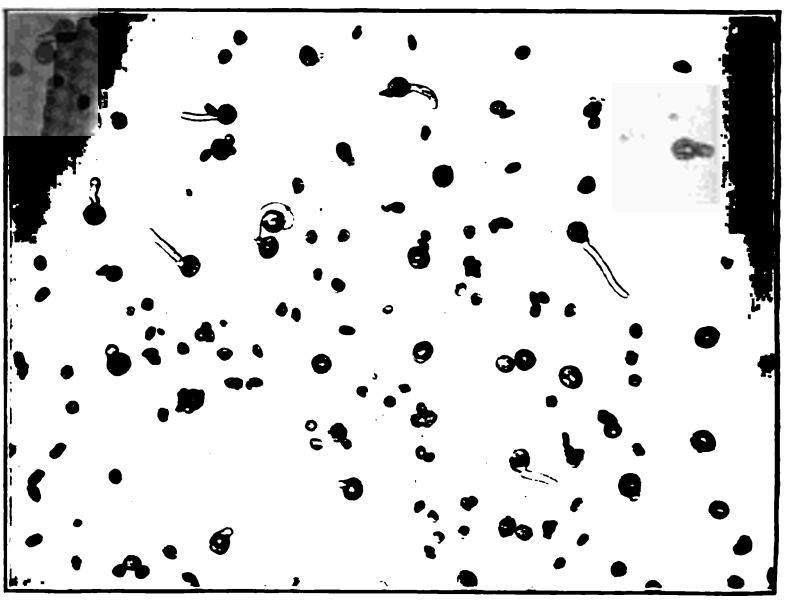


Figure 2. Micro-photograph of *Rubus brainerdi* Rydb., 121-1. Germinated in a hanging drop culture of 12 percent cane sugar solution for one hour. X 85.

PLATE XV.

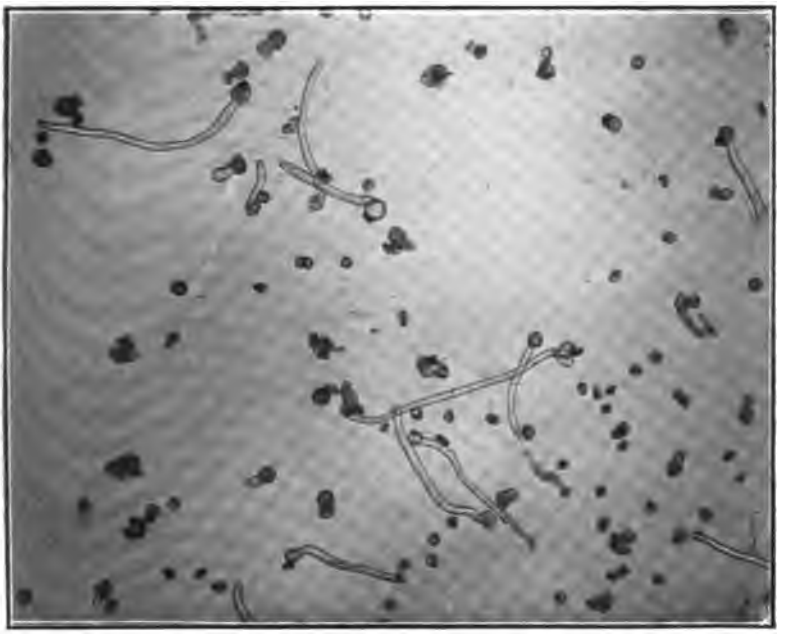


Figure 1. Micro-photograph of pollen grains of *Rubus setosus* Bigelow, 119-2. Germinated in a hanging drop culture of 12 percent cane sugar solution for 12 hours. X 85.

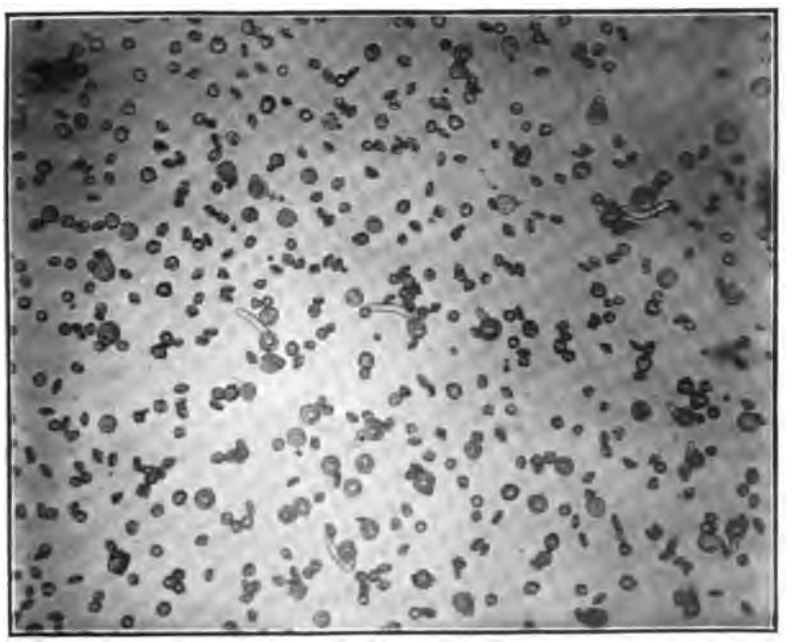


Figure 2. Micro-photograph of pollen grains of *Rubus vermontanus* Blanchard, 12-3. Germinated in a hanging drop culture of 12 percent cane sugar solution for three and one-half hours. X 85.

PLATE XVI.

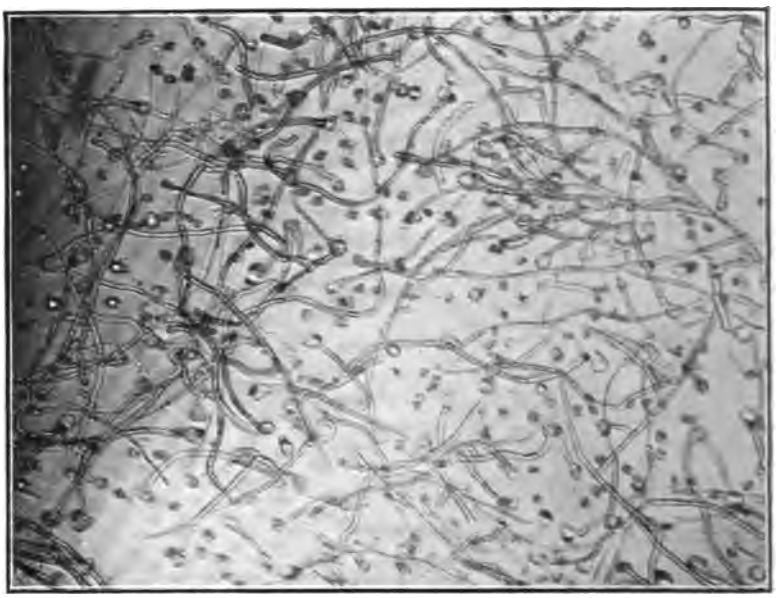


Figure 1. Micro-photograph of pollen grains of *Rubus alleghenicnsis* × *hispidus*, 205-1 (*Rubus permixtus* Blanchard). Germinated in a hanging drop culture of 12 percent cane sugar solution for 24 hours. X 85.

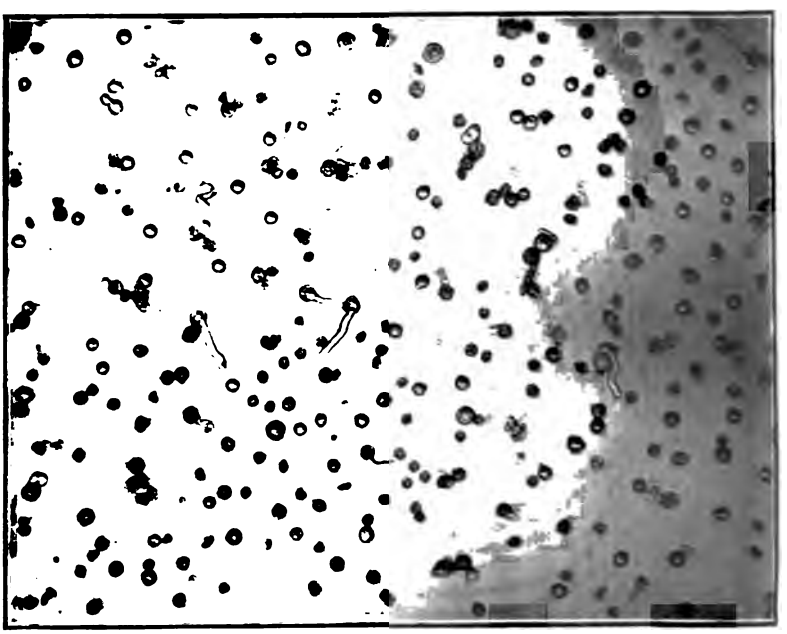
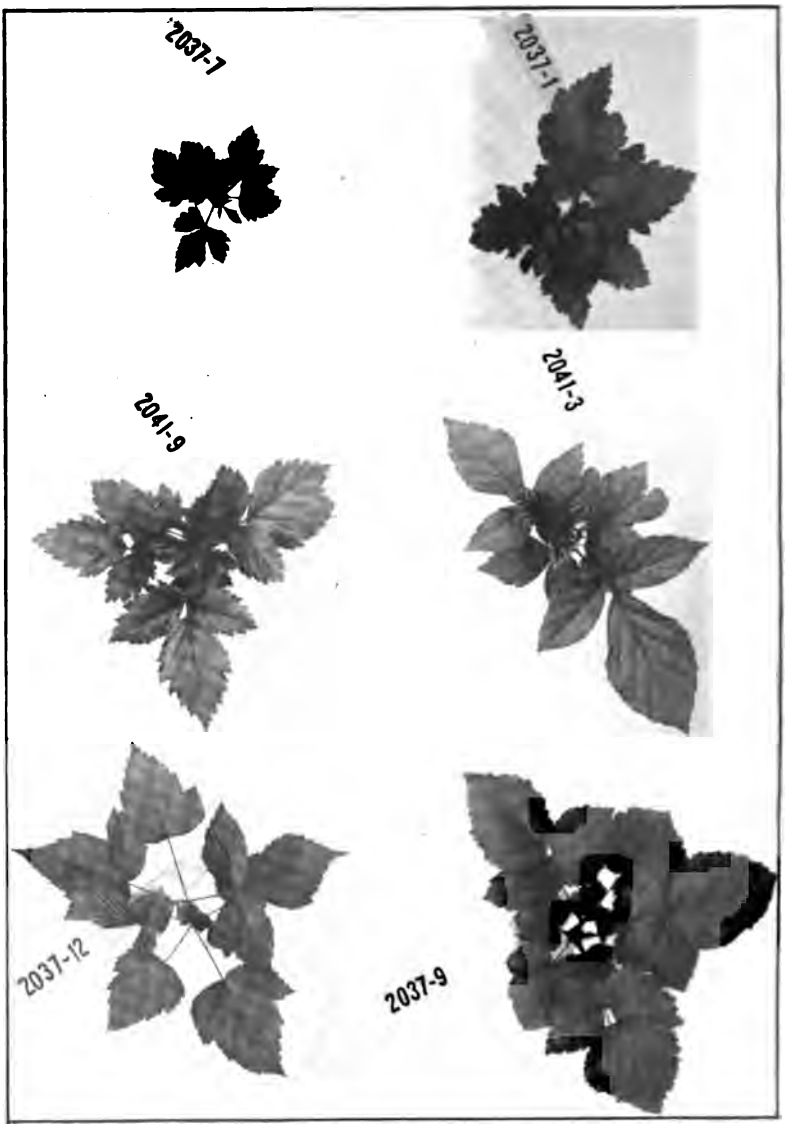


Figure 2. Micro-photograph of pollen grains of *Rubus alleghenicnsis* × *frondosus*, 7-2. Germinated in a hanging drop culture of 12 percent cane sugar solution for one hour. X 85.

Inside view of cage at Vermont Experiment Station in which the hybridization work was done.

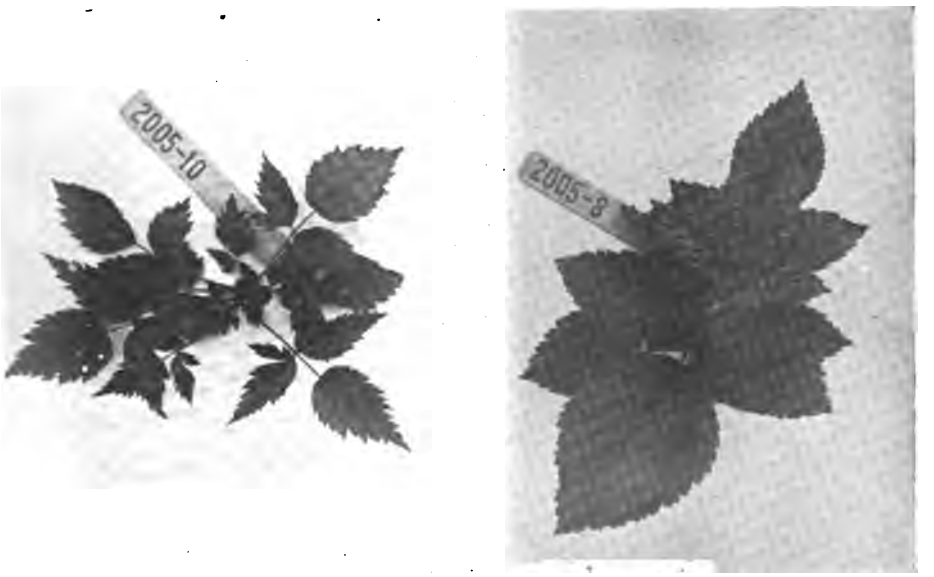
PLATE XVIII.



Seedlings from selfed flowers of natural hybrids showing segregation. Plants Nos. 2041-9 and 2041-3 were grown from seed of selfed flowers of No. 14-2 *Rubus jacens* Blanchard. Plant No. 2041-9 is an almost perfect reversion to *Rubus setosus* Bigelow, while plant No. 2041-3 is a reversion to *Rubus hispidus* L.

Plants Nos. 2037-1, 2037-7, 2037-9 and 2037-12 were grown from seeds of selfed flowers of No. 7-1, *R. alleghenienses* × *frondosus*. Showing some of the different variations in the shape of the leaves.

PLATE XIX.



Rubus allegheniensis × *frondosus*

Two seedlings from selfed flowers of plant No. 122-1, which is a suspected natural hybrid showing reversions to the parent types. Plant No. 2005-8 shows a reversion towards *Rubus frondosus* Bigelow in the orbicular shape of its terminal leaflet. Plant No. 2005-10 shows a reversion towards *Rubus allegheniensis* Porter in having a narrow, ovate terminal leaflet. These are the two extreme variants.

2. The percentage of infertility in any given species or distinct form is quite constant. In some instances this may seem quite contradictory to the data given. As for example, in *R. trifrons* Blanchard, five plants show a very high percentage of infertility, while five others are comparatively quite fertile. In this case we have two distinct forms of *R. trifrons* Blanchard. One form—*R. jacens* Blanchard in part—has a very shiny leaf and in other characters resembles somewhat the dewberry type, while the other form has more of the character of *R. setosus* Bigelow. These two distinct forms of *R. trifrons* Blanchard were noted and labeled as such long before these experiments were begun. This, however, only emphasizes the fact that the percentage of infertility in a given plant is a very important taxonomic character.

3. All species of Rubus studied are either completely self-sterile or nearly so, as shown by the results obtained by bagging the flowers. There may be some chance of error in these figures, as has already been pointed out, although other studies with the same plants bear out the accuracy of these tabulated results.

A very interesting fact in reference to *R. allegheniensis* Porter is here shown. These plants which represent the most monotypic species in the whole blackberry group and whose pollen is morphologically more perfect than any of the others (table VIII, p. 21) were completely self-sterile. Numerous other attempts were made to close fertilize these plants but all failed. An explanation of the cause of self-sterility found in some monotypic forms of plants has been attempted by various workers, but all that may be concluded from the data here presented is that most blackberries are more or less completely self-sterile.

ABORTED POLLEN IN RUBUS

It has been found that sterility among the plants studied is largely due to the degeneration of the microspores after the second division of the spore-mother cell has been completed. This degeneration of the microspore after its initial formation by the homotypic division of the spore-mother cell results in the development of aborted or sterile pollen grains. These aborted grains are present to a more or less extent in all blackberries (plates V to XII, inclusive) and may be readily seen by the aid of a low power microscope if the mature pollen is mounted in water or a sugar solution.

This type of sterility is common among other groups of flowering

plants according to different investigators (20, 13, 15). It is a common phenomenon among hybrid or cryptohybrid forms. According to Bateson (11) it is an indication of the hybrid origin of the particular plant in which it is found.

The pollen from available forms of blackberries growing in the Vermont Station gardens was examined and the percentages of aborted pollen grains were computed. This was done by mounting the pollen from the anthers of newly unfolded flowers in a 12 percent solution of cane sugar. The eye-piece of the microscope used in counting the grains was equipped with a "netzmikrometer" scale. Both the normal and the aborted grains falling within a certain area of the field marked out by the squares in the scale were counted. Two hundred or more grains were included in each count. Table VII gives the average results of five such counts made from as many different flowers taken from different parts of the same plant. A similar study was made with all available plants growing in the wild. Table VIII (p. 21) gives a summary of data obtained. The micro-photographs shown in plates V to XII, inclusive, show this

TABLE VII. SHOWING PERCENTAGE OF ABORTED GRAINS IN CERTAIN SPECIES OF RUBUS GROWING UNDER CULTIVATION

No.	Plant name	Percentage aborted grains
4-1	*R. allegheniensis* Porter	4.00
212-1	*R. allegheniensis* Porter	6.50
116-1	*R. flagellaris* Willd.	10.75
216-2	*R. baileyanus* Britton	11.05
137-4	*R. abbrevians* Blanchard	11.60
136-1	*R. frondisentis* Blanchard	12.15
8-2	*R. baileyanus* Britton	13.65
205-1	*R. permixtus* Blanchard	46.85
211-1	*R. plicatifolius* Blanchard	65.00
215-1	*R. plicatifolius* Blanchard	65.00
7-2	*R. allegheniensis* × *frondosus*	69.25
17-4	*R. frondosus* Bigelow	72.00
105-8	*R. groutianus* Blanchard	72.00
134-4	*R. groutianus* Blanchard	77.75
17-5	*R. frondosus* Bigelow	77.75
17-1	*R. frondosus* Bigelow	78.75
256-3	*R. elegantulus* Blanchard	78.75
220-3	*R. andrewsianus* Blanchard	81.75
34-1	*R. setosus* Bigelow	81.95
121-3	*R. brainerdi* Rydb.	82.75
121-1	*R. brainerdi* Rydb.	83.50
12-3	*R. vermontanus* Blanchard	84.80
12-4	*R. vermontanus* Blanchard	87.00
14-2	*R. jacens* Blanchard	88.14
13-2	*R. canadensis* L.	91.34
203-1	*R. hispidus* Bigelow	93.75
119-2	*R. setosus* Bigelow	94.50
13-1	*R. orarius* Blanchard	94.50

variation in the number of aborted grains in some of the species and hybrids studied. These micro-photographs not only show a large difference in the percentage of aborted pollen but also a difference in the size of the normal pollen grains (all the grains shown in these plates are 85 diameter magnifications). This difference in the size of the normal pollen grains is interesting in that there seems to exist a correlation between the size of the mature "seed" and the size of the pollen. The small-sized "seeds" and the small-sized pollen grains are characteristics of the high-bush blackberries of the

TABLE VIII. SHOWING PERCENTAGE OF ABORTED GRAINS IN CERTAIN SPECIES OF RUBUS COLLECTED IN THE WILD

Plant name	Percentage aborted grains
R. allegheniensis Porter	4.45
R. baileyanus Britton	9.84
R. frondisentis Blanchard	9.86
R. enslenii Tratt.	11.14
R. abbrevians Blanchard	12.46
R. flagellaris Willd.	12.81
R. invisus (Bailey) Britton	14.84
R. argutus L.	21.24
R. permixtus Blanchard	51.14
R. jeckylanus Blanchard	58.88
R. glandicaulis Blanchard	59.14
R. fraternis B. & P.	61.15
R. plicatifolius Blanchard	64.85
R. recurvans var. subrecurvans Blanchard	64.85
R. multispinus Blanchard	65.30
R. flavinanus Blanchard	66.90
R. baileyanus × *hispidus*	68.14
R. pergratus Blanchard	68.45
R. elegantulus Blanchard	68.94
R. allegheniensis × *frondosus*	69.25
R. allegheniensis × *pergratus*	74.12
R. canadensis × *elegantulus*	74.68
R. elongatus B. & P.	74.80
R. groutianus Blanchard	75.16
R. frondosus Bigelow	77.14
R. arenicola Blanchard	77.68
R. setosus Bigelow	79.81
R. andrewsianus Blanchard	81.04
R. junceus Blanchard	82.25
R. brainerdi Rydb.	83.15
R. jacens Blanchard	84.16
R. canadensis L.	84.64
R. elegantulus × *vermontanus*	86.04
R. vermontanus Blanchard	86.12
R. trifrons Blanchard	87.94
R. frondosus × *vermontanus*	88.24
R. canadensis × *pergratus*	89.42
R. semisetosus Blanchard	90.81
R. vermontanus var. viridifolius Blanchard	91.45
R. cubitans Blanchard	92.15
R. hispidus L.	92.45
R. orarius Blanchard	94.50

R. allegheniensis Porter type while the procumbent types are large "seeded" and have comparatively large pollen. This can be seen from table IX, which gives the average size of both "seed" and pollen grain of New England species.

TABLE IX. GIVING WEIGHT OF "SEEDS" AND DIAMETER OF POLLEN GRAINS OF NEW ENGLAND SPECIES OF RUBI

Name	Average weight of "seed" in mg.	Average diameter of pollen grain in microns
R. allegheniensis Porter	15.96	21.75
R. argutus Link	16.40	21.90
R. pergratus Blanchard	18.70	24.15
R. frondosus Bigelow	19.12	24.10
R. frondosus Bigelow, form *recurvans* Blanchard	19.10	24.30
R. canadensis L.	20.19	23.40
R. elegantulus Blanchard	20.15	24.75
R. vermontanus Blanchard	28.60	25.00
R. setosus Bigelow	31.40	28.75
R. hispidus L.	35.42	31.15
R. flagellaris Willd.	34.53	29.70
R. enslenii Tratt.	36.53	29.04
R. baileyanus Britton	38.60	30.65

The data presented in the three preceding tables may be summarized as follows:

1. The amount of aborted pollen in the different species varies from 4.00 percent in *R. allegheniensis* Porter to 94.5 percent in *R. setosus* Bigelow and *R. allegheniensis* × *canadensis*. The species showing the least amount of aborted pollen are either the extreme high-bush type like *R. allegheniensis* Porter or the extreme procumbent type like *R. flagellaris* Willd., *R. baileyanus* Britton and *R. enslenii* Tratt. The intermediate species and hybrids show a comparatively large amount of aborted pollen.

2. The size of the pollen grains as well as the size of the "seed" show this same general variation. The high-bush types of blackberry have comparatively small pollen grains and small "seeds," while in the procumbent blackberries the reverse is true.

STERILITY AS SHOWN BY POLLEN GERMINATION

The mature pollen grain may in some instances be perfectly normal both in appearance and size and yet not be functional. Dorsey (19), working with the grapes and Geertz (25) working with the evening primroses, found this to be of common occurrence. Sand-

sten (17), Martin (23), and others (22), working on the physiology of the pollen of various fruits and agricultural plants, compute the amount of sterility in a given species by the percent of grains capable of germinating in a certain medium. The results thus obtained would be based upon the amount of apparently functional pollen. However, the variation shown in the germinating power of the same pollen in different media and under different light and temperature conditions makes this method unreliable except for comparative studies. Adams (22) found in working with the pollen of the apple and other members of the Rosaceæ family that a temperature of 21° to 23° C. gave the quickest germination and that the best germination was obtained in a cane sugar solution of varying percentage, depending upon the species used. He gives the following as the optimum concentration for pollen germination in the plants named: Apple 2.5-10 percent, pear 4-8 percent, strawberry 8 percent, loganberry 4 percent, raspberry 16 percent, black currant 16 percent. Sandsten (17) in an earlier work obtains somewhat similar results. He also showed that light affects the direction of growth of the pollen tube.

In order to check the reliability of aborted pollen as an index of sterility a comparative study was made of pollen germination in all plants listed in table VII (p. 20). Pollen from newly dehisced anthers were used. Various nutrient media were tried, including glycerin, olive oil, glucose, stigma and style decoctions, etc., but a 12 percent cane sugar solution gave the best results and this medium and concentration were used in all later germination tests. In sugar solutions of 9 percent or less concentration the pollen tubes would grow to a certain length and then burst, while in a solution of greater concentration than 12 percent the growth was retarded or completely checked. The optimum temperature for the germination of the pollen was found to be 22° C. The pollen was mounted in ordinary hanging drop culture slides similar to the ones used by Sandsten (17), but an opening was left between the slide and the cover-glass so as to admit the air from the outside. These were then placed in a dark, moist air germinator gauged at a temperature of 22° C. and left to germinate for 24 hours when the final count was made. Table X gives the average results of counts made from four such mounts of pollen taken from at least four different flowers on the same plant. Plates XIII to XVI, inclusive, are micro-photographs of some of these mounts, showing the difference in germination.

By a comparison of the percentage germination and the percentage of aborted pollen in the given species (tables VII and X, pp. 20 and 24) it will be seen that in some plants (like *R. allegheniensis* × *frondosus*) a large number of grains failed to develop pollen tubes. This would indicate a relatively large amount of normal-sized, sterile pollen, while in species like *R. allegheniensis* Porter little or no morphologically perfect pollen is functionless.

TABLE X. SHOWING PERCENTAGE OF POLLEN GERMINATION

No.	Plant name	Percentage of pollen germinating
121-1	*R. brainerdi* Rydb.	1.00
203-1	*R. hispidus* L.	1.00
119-2	*R. setosus* Bigelow	1.00
121-3	*R. brainerdi* Rydb.	1.10
34-1	*R. setosus* Bigelow	1.18
220-3	*R. andrewsianus* Blanchard	1.20
215-1	*R. plicatifolius* Blanchard	1.25
13-1	*R. orarius* Blanchard	1.52
13-2	*R. canadensis* L.	2.72
12-4	*R. vermontanus* Blanchard	2.75
12-3	*R. vermontanus* Blanchard	2.80
134-4	*R. groutianus* Blanchard	3.95
256-3	*R. elegantulus* Blanchard	4.20
14-2	*R. jacens* Blanchard	4.28
105-8	*R. groutianus* Blanchard	4.30
17-4	*R. frondosus* Bigelow	4.40
17-5	*R. frondosus* Bigelow	4.52
17-1	*R. frondosus* Bigelow	4.55
7-2	*R. allegheniensis* × *frondosus*	5.00
211-1	*R. plicatifolius* Blanchard	6.75
136-1	*R. frondisentis* Blanchard	39.94
137-4	*R. abbrevians* Blanchard	46.12
205-1	*R. permixtus* Blanchard	53.00
216-2	*R. baileyanus* Britton	59.33
8-2	*R. baileyanus* Britton	64.24
116-1	*R. flagellaris* Willd.	82.00
212-1	*R. allegheniensis* Porter	93.50
4-1	*R. allegheniensis* Porter	94.50

A great difference in the rapidity of growth of the pollen tubes was noted for the different species (table XI, p. 25). It was found by a series of repeated tests that the growth of the pollen tube was quite constant for a given species, but varied greatly for the different species or forms. Table XI (p. 25) shows the rapidity of growth of the pollen tubes of some of the common forms of blackberries. These pollen grains were germinated in a 12 percent cane sugar solution as previously described. The length given in every instance is the average of 12 measurements from four such mounts. The measurements for the length of the pollen tube are quite reliable

for the first eight hours of the germination period, since the cultures were almost free from bacterial growth during that time. After being in the germinator for 12 hours the cultures were as a rule affected by the growth of fungi or bacteria, which would necessarily make the measurements then obtained more unreliable.

TABLE XI. SHOWING THE DIFFERENCE IN THE RATE OF GROWTH OF THE POLLEN TUBES

Name	Average length of pollen tubes in microns after germinating in a 12 percent sugar solution for ½ hr.	1 hr.	2 hrs.	3 hrs.	4 hrs.	8 hrs.	24 hrs.
R. baileyanus Britton	16	32	190	312	558	1146	1377
R. permixtus Blanchard	24	44	146	280	449	711	848
R. enslenii Tratt.	18	30	138	308	510	1016	1248
R allegheniensis Porter	16	42	140	218	332	480	746
R. abbrevians Blanchard	14	35	120	198	304	468	704
R. frondosus Blanchard	4	21	93	182	276	475	725
R. flavinanus Blanchard	5	24	59	83	158	316	498
R. brainerdi Rydb.	5	26	55	79	125	293	466
R. andrewsianus Blanchard	0	1	32	94	103	231	449
R. pergratus Blanchard	2	12	18	35	70	180	416
R. vermontanus Blanchard	1	11	16	32	64	173	400
R. setosus Bigelow	11	16	48	73	92	177	325
R. canadensis L.	0	0	29	88	156	316	347
R. hispidus L.	0	0	16	32	108	204	278
R. trifrons Blanchard	0	0	12	20	32	100	244

An attempt was made to determine the comparative rapidity of growth of the pollen tube as it penetrates the style. Several flowers of *R. vermontanus* Blanchard were emasculated and bagged in the usual manner. Two days later one-half of these emasculated flowers were pollinated with the pollen from *R. permixtus* Blanchard, while the other half were pollinated with the pollen from another plant of *R. vermontanus* Blanchard. A number of these flowers were then "fixed" in a chromo-acetic acid killing solution, 12, 24 and 30 hours after pollination had been effected. Later, cytological studies of these flowers showed that fertilization took place at least six hours earlier in the flowers which had been pollinated with pollen from *R. permixtus* Blanchard than in the flowers which had been close-pollinated.

If there is such a difference in the rate of growth of the pollen tubes as shown in the preceding data, then in the wild, where insect cross-pollination is the rule, it becomes a very important factor in reference to spontaneous hybridization. This difference in the rate of growth of the pollen tube may account for the very frequent occurrence of certain natural hybrids and the less frequent occurrence or entire absence of other hybrid forms although the two parent species may be growing side by side.

STERILITY AS SHOWN BY HYBRIDIZATION

If spontaneous hybridization takes place among the different species of wild blackberries, as would seem highly probable from the data obtained in the preceding studies, it should be possible to produce similar hybrids by artificial cross-fertilization.

The difficulty of selecting the elementary species from among the now existing numerous forms by the ordinary taxonomic means becomes obvious. After a thorough systematic study of the group, however, certain plants were selected which showed marked specific differences and which were suspected of interbreeding. These in particular were used in hybridization work.

The plants were grown in a cage covered with ordinary galvanized mosquito netting (plate XVII) which not only protected the bags and plants from insect injury, but also from being tampered with by intruders. All cross-fertilization work, which was done by the usual bagging method, was carried on inside this cage.

In order to determine the earliest time at which self-pollination might occur, a series of checks were used similar to those used by Wellington (26) in working with the raspberries. Flowers in different stages of development were emasculated and bagged in the usual manner. These were then left without being pollinated. Table XII (p. 27) shows in detail the number of flowers of the species and hybrids used and their stages of development when emasculated. The lower number represents the number of flowers emasculated, while the upper represents the number of seeds formed. In no instances were there any seeds formed where emasculation had been affected prior to the time when the corolla opened and there were but four seeds formed from the entire series of checks. Cytological examination of the flowers also revealed the fact that the pollen sacs do not split open until after the corolla has unfolded. For the sake of precaution, however, all flowers used in the hybridization work were emasculated before the splitting of the calyx took place. Checks were also used in most cases.

The crosses affected during the seasons 1914, 1915 and 1916 are summarized in table XIII (p. 28). The lower number represents the number of flowers cross-pollinated, while the upper represents the number of seeds formed. It will be noted that in nearly all flowers cross-pollinated where "good" pollen was used a large percent of ovules formed seeds. Flowers pollinated with pollen

TABLE XII. SHOWING CHECKS USED IN CROSS-FERTILIZATION WORK

The lower number represents the number of flowers emasculated and the upper number represents the number of seeds formed.

	Very young flowers	About two days before calyx split	About one day before calyx split	Calyx beginning to split	Corolla just showing	Corolla quite conspicuous	Just before corolla unfolds	Just after corolla has unfolded
R. canadensis L.	0 3	0 6	0 6	0 11	0 2	0 8	0 4	0 6
R. allegheniensis Porter	0 4	0 2	0 7	0 12	0 8	0 14	0 3	0 8
R. vermontanus Blanchard	0 2	0 11	0 14	0 3	0 7	0 7	0 6	0 12
R. frondosus Bigelow	0 1	0 6	0 11	0 3	0 4	0 6	0 8	4 14
R. allegheniensis × *frondosus*		0 3	0 5	0 4	0 5	0 4	0 1	0 13

from plants such as *R. allegheniensis* Porter or *R. baileyanus* Britton gave a greater percent of mature seeds than if these same plants had been close-pollinated (see table VI, p. 18). On the other hand, whenever a form having a large amount of aborted pollen was used as the male parent comparatively few ovules developed seeds. It will also be noted that none of the attempted crossings failed to produce viable seeds where a reasonable number of flowers were used. The few flowers in which no seed were developed may have been somewhat injured during the process of emasculation or pollination may not have been affected at the proper time.

TABLE XIII. SHOWING CROSSES MADE DURING 1914, 1915 AND 1916. THE LOWER NUMBER REPRESENTS THE NUMBER OF FLOWERS CROSS-POLLINATED WHILE THE UPPER NUMBER REPRESENTS THE NUMBER OF SEEDS FORMED

	R. allegheniensis Porter ♀	*R. andrewsianus* Blanchard ♀	*R. permixtus* Blanchard ♀	*R. allegheniensis* × *frondosus* ♀	*R. orarius* Blanchard ♀	*R. frondosus* Blanchard ♀	*R. canadensis* L. ♀	*R. vermontanus* Blanchard ♀	*R. setosus* Bigelow ♀	*R. baileyanus* Britton ♀	*R. jacens* Blanchard ♀
R. allegheniensis Porter ♂		170 7		230 9	1024 35	157 14	143 7	147 4	124 9		
R. andrewsianus Blanchard ♂						2 2					
R. permixtus Blanchard ♂						28 3					
R. allegheniensis × *frondosus* ♂	290 9			2 3		11 1	4 1				
R. orarius Blanchard ♂	70 12										
R. frondosus Blanchard ♂	60 3	2 1			21 11		14 3	3 1		11 1	
R. canadensis L. ♂	22 3				8 4	2 5					
R. vermontanus Blanchard ♂	3 1				22 10	22 2	3 2				5 4
R. setosus Bigelow ♂	2 1						14 8				
R. baileyanus Britton ♂						0 1	18 3				
R. jacens Blanchard ♂							34 8	38 4			23 5
Average number of ovules per flower	84	72	29	66	77	72	68	42	38	46	23

The above data would indicate:

1. That sterility among the blackberries is largely due to defective pollen.

2. That all blackberries are capable of inter-breeding under favorable conditions for doing so, since some of the crosses effected were between plants as remotely related as *any* two species of Eubatus.

THE FIRST GENERATION OF ARTIFICIAL HYBRIDS

The seeds produced by the hybridization work as outlined in table XIII were collected (the original bags having been left enclosing the flower until the drupelets had fully matured) and planted in sand in the ordinary greenhouse flats. It was found that if the fruit were left in a glass tumbler to ferment for a few hours, the pulp could

more easily be removed. All sand used for planting was thoroughly heated in a dry oven in order to kill any seeds that might be present as it was found that nearly all New England surface soil contains blackberry and raspberry seeds in quite large numbers. These have undoubtedly been carried by birds. The flats were then placed outdoors in a cage where they were also protected by a layer of cloth. It was found that some of the seed of the dewberry types would germinate the following spring, but most of the high-bush forms require two years for germination. Table XIV shows the number of seedlings obtained from these plantings. Some of these were winter-killed during the first year, but at present there are representatives of most of these hybrids growing in the Vermont Station gardens. All of these plants show a more or less degree of intermediacy between the two parent forms not only in respect to the shape of leaf and the character and abundance of simple hairs, gland-tipped hairs and prickles, but also in respect to the type of flower and fruit in those cases where the plants are mature enough to form these structures. For example, the 10 plants obtained from the cross effected in the spring of 1914 between No. 4-1, *R. allegheniensis* Porter as the pistillate plant and No. 17-3, *R. frondosus* Bigelow as the staminate

TABLE XIV. SHOWING NUMBER OF HYBRID PLANTS GROWN FROM SEED PRODUCED BY ARTIFICIALLY FERTILIZED FLOWERS

Parent plants	Number of seedlings grown
**R. allegheniensis* Porter × *R. allegheniensis* × *frondosus*	78
R. allegheniensis Porter × *R. andrewsianus* Blanchard	10
**R. allegheniensis* Porter × *R. canadensis* L.	101
**R. allegheniensis* Porter × *R. frondosus* Bigelow	52
**R. allegheniensis* Porter × *R. orarius* Blanchard	121
**R. allegheniensis* Porter × *R. setosus* Bigelow	110
**R. allegheniensis* Porter × *R. vermontanus* Blanchard	41
R. allegheniensis × *frondosus* × *R. canadensis* L.	3
R. allegheniensis × *frondosus* × *R. frondosus* Bigelow	4
**R. andrewsianus* Blanchard × *R. frondosus* Bigelow	1
R. baileyanus Britton × *R. canadensis* L.	6
R. baileyanus Britton × *R. frondosus* Bigelow	8
**R. canadensis* L. × *R. frondosus* Bigelow	11
R. canadensis L. × *R. jacens* Blanchard	12
R. canadensis L. × *R. orarius* Blanchard	1
R. canadensis L. × *R. setosus* Bigelow	3
R. frondosus Bigelow × *R. orarius* Blanchard	7
R. frondosus Bigelow × *R. permixtus* Blanchard	12
R. frondosus Bigelow × *R. vermontanus* Blanchard	16
**R. jacens* Blanchard × *R. vermontanus* Blanchard	23
R. orarius Blanchard × *R. vermontanus* Blanchard	3

*Reciprocal crosses are included in this number.

plant are almost duplicates of No. 7-1, which was found growing four miles north of Burlington and which is a suspected wild hybrid between *R. allegheniensis* Porter and *R. frondosus* Bigelow. The same is true in general of the other hybrid plants produced artificially, their duplicate have in most cases been found growing in the wild.

SEGREGATION IN NATURAL HYBRIDS

Seedlings were grown from the selfed flowers of nearly all the

TABLE XV. GIVING A SUMMARY OF THE VARIATION FOUND IN THE PROGENY OF SELFED PLANTS

Name of plant	Degree of variation
R. abbrevians Blanchard	Somewhat variable
R. allegheniensis Porter	Not variable
R. allegheniensis × *frondosus*	Very variable
R. andrewsianus Blanchard	Very variable
R. arenicola Blanchard	Somewhat variable
R. baileyanus Britton	Not variable
R. baileyanus × *hispidus*	Very variable
R. brainerdi Rydb.	Somewhat variable
R. canadensis L.	Not variable
R. cubitans Blanchard	Very variable
R. elegantulus Blanchard	Not variable
R. flagellaris Willd.	Not variable
R. falvinanus Blanchard	Very variable
R. frondisentis Blanchard	Not variable
R. frondosus Bigelow	Somewhat variable
R. groutianus Blanchard	Very variable
R. hispidus L.	Not variable
R. jacens Blanchard	Extremely variable
R. junceus Blanchard	Very variable
R. orarius Blanchard	Very variable
R. pergratus Blanchard	Not variable
R. permixtus Blanchard	Somewhat variable
R. recuvicaulis Blanchard	Variable
R. setosus Bigelow	Not variable
R. trifrons Blanchard	Extremely variable
R. vermontanus Blanchard	Not variable

wild forms of blackberries grown in the Vermont Station gardens. The seeds from which these plants were grown were treated in the same manner as those germinated in the hybridization work which has already been discussed. Many of these plantings show very clearly a more or less complete reversion towards two or more of the stable forms of blackberries. None of the first generation plants showed any well-defined Mendelian segregation. There always occur a large number of variants between the two extreme forms and the differences between the individual plants of any given progeny were so slight that no definite class-groups could be made. The data obtained from these sowings are summarized in table XV. The terms "extremely

variable," "very variable," "variable," "somewhat variable," and "not variable" are used to designate in a general way the degree of variation found within a given progeny. Several individual sowings with the seeds of plants taken from different stations are represented in each of the bi-nomials given in this table. Plates XVIII. and XIX. are photographs of several seedlings showing segregation.

Such segregation as noted above can only occur in plants of hybrid origin. The following natural hybrids show a definite segregation towards the species given opposite them and may, therefore, be assumed to have been produced by these species hybridizing in the wild:

R. allegheniensis × *frondosus* .....*R. allegheniensis* × *frondosus*
R. andrewsianus Blanchard .....*R. allegheniensis* × *argutus*
R. arenicola Blanchard .....*R. baileyanus* × *frondosus*
R. baileyanus × *hispidus* .....*R. baileyanus* × *R. hispidus*
R. cubitans Blanchard .....*R. hispidus* × *vermontanus*
R. flavinanus Blanchard .....*R. allegheniensis* × *elegantulus*
R. groutianus Blanchard .....*R. elegantulus* × *setosus*
R. jacens Blanchard .....*R. hispidus* × *setosus*
R. junceus Blanchard .....*R. canadensis* × *setosus*
R. orarius Blanchard .....*R. allegheniensis* × *canadensis*
R. permixtus Blanchard .....*R. allegheniensis* × *hispidus*
R. trifrons Blanchard .....*R. hispidus* × *setosus*

Based upon other hybrid characters aside from segregation in the offspring, other so-called species have been assumed to be spontaneous hybrids. These have already been treated in a recent bulletin from this Station (1).

GENERAL DISCUSSION OF THE RESULTS OF THE EXPERIMENT

It has been shown that inter-breeding among the many different species of blackberries is easily effected. It would, therefore, seem highly probable that such inter-breeding occurs spontaneously in a group like this where insect cross-pollination is the rule. That such inter-breeding does occur seems evident from the variability which characterizes the entire group. That the individual forms within this group should be so variable and that all so-called species of blackberries should have certain marked characters in common, seems to indicate their common origin through hybridization. Moreover, the progeny of a large number of these so-called species shows segrega-

tion towards the more stable forms which is an unmistakable character of hybrids.

The pronounced difference in the amount of sterility and other hybrid characters in the different species seems to indicate that all the present New England forms have been brought about by the interbreeding of two or more elementary species. These are now represented by the extreme high-bush type as *R. alleghenicnsis* Porter and the extreme procumbent type as *R. baileyanus* Britton or *R. enslenii* Tratt. If such is the case, the several intermediate stable forms, such as *R. setosus* Bigelow, *R. vermontanus* Blanchard, etc., are simply remotely or recently formed cryptohybrids. This would account for the great amount of sterility found in these species.

SUMMARY

1. Variations due to external factors are very marked in the plants of the Eubatus group. This is especially true in reference to protodermal outgrowths. Their development depends largely upon external factors and they are, therefore, of little taxonomic value.

2. Light seems to be the determining factor affecting the development of protodermal outgrowths.

3. The primordia of the prickle, glandular hair, and simple hair are present in all species of blackberries. The prickle and glandular hair are morphologically simple and the former may develop from the latter.

4. A large percentage of infertility occurs in most species of blackberries. This is shown not only by the large amount of aborted pollen present in most species, but also by bagging, pollen germination. and hybridization experiments.

5. Sterility among the blackberries is largely due to defective pollen.

6. The percentage of infertility in a given species is quite constant. This has been shown by several methods.

7. The two extreme types of blackberries, *R. alleghenicnsis* Porter and *R. baileyanus* Britton, show less infertility and other hybrid characters than any of the intermediate species or forms.

8. These two types possess certain well-marked quantitative characters, such as size of seed, size of pollen grain, etc., which are present in compromise form in all the intermediate species and forms.

9. Cross-pollination is the rule in all species of blackberries. All species of Rubus studied are either nearly or completely self-sterile.

10. All New England blackberries are capable of inter-crossing under favorable conditions for doing so.

11. Duplicates of natural hybrids have been produced by artificial hybridization.

12. The progeny of a number of so-called species of blackberries segregate, a character which is present only in organisms of hybrid origin.

13. In view of the data presented, it is concluded that spontaneous hybridization is quite common in the Eubatus group and that a large number of the so-called species are either hybrids or crypto-hybrids brought about probably by the inter-breeding of two or more elementary species.

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